
# *Waveland Lake*
# *Aquatic Vegetation Management Plan*

February 21, 2005

Prepared for:
Waveland Lake Department of Parks and Recreation
P.O. Box 186
Waveland, IN 47989

Prepared by:
Nathan W. Long
Aquatic Control, Inc.
PO Box 100
Seymour, Indiana 47274

## Executive Summary

Aquatic Control was contracted by the Waveland Lake Department of Parks and Recreation to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Waveland Lake Department of Parks and Recreation and the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was also created as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Aquatic vegetation is an important component of lakes in Indiana; however, as a result of many factors this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, describes plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, aesthetic, and lakefront property values. At the time of the survey the primary nuisance species within Waveland Lake was coontail (*Ceratophyllum demersum)* which is a native species to Indiana. The exotic species curlyleaf pondweed (*Potamogeton crispus*) was present, but not at nuisance levels. It is likely that this species reaches nuisance levels in spring and early summer. Another exotic species, Eurasian watermilfoil (*Myriophyllum spicatum),* was observed at only a single site. This exotic species can quickly spread and create nuisance conditions. It is important that Eurasian watermilfoil be controlled in order to prevent its spread. The negative impact of this species on native aquatic vegetation, fish populations, water quality, and other factors is well documented and will be discussed in further detail. The primary recommendation for plant control within Waveland Lake includes the use of contact herbicides in order to reduce nuisance conditions in high use areas. Along with this treatment, a plant survey should be conducted in May of 2005 in order to document curlyleaf pondweed areas and to locate any Eurasian watermilfoil beds. Eurasian watermilfoil should be treated with a systemic herbicide in order to keep this species from spreading throughout the lake.

# Acknowledgements

Funding for the vegetation sampling and preparation of an aquatic vegetation management plan was provided by the Indiana Department of Natural Resources – Division of Soil Conservation and the Waveland Lake Department of Parks and Recreation. Aquatic Control Inc completed the field work, data processing, and map generation. Identification and verification of some plant specimens was provided by Dr. Robin Scribailo of Purdue University North Central. Special thanks are due for Larry Servies of the Waveland Department of Parks and Recreation for his help in initiating and completing this project. Special thanks are given to the public for their valuable input and suggestions at the November meeting. Special thanks are given to Mr. Rhett Wiesner, Mr. Cecil Rich and Mr. Doug Keller with the Indiana Department of Natural Resources for their assistance and review of this project. Author of this report is Nathan Long of Aquatic Control. The author would like to acknowledge the valuable input from David Isaacs, Brian Isaacs, Joey Leach, and Barbie Huber of Aquatic Control for their field assistance, map generation, review, and editing of this report.

## Table of Contents

## List of Figures

## List of Tables

## List of Appendices

## Introduction

Aquatic Control was contracted by the Waveland Lake Department of Parks and Recreation to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was also created as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

At the time of the plant survey, the native species coontail was creating nuisance conditions in high use areas. Curlyleaf pondweed was present at low levels, but likely creates nuisance conditions in late spring and early summer. The exotic species Eurasian watermilfoil was visually documented in one area of the lake. It is important that the spread of this species be controlled. The primary vegetation management goal of the Waveland Lake Parks Department is the reduction of nuisance conditions caused by submersed vegetation with special attention focused on limiting the spread of the exotic species Eurasian watermilfoil and curlyleaf pondweed.

## Watershed and Water Body Characteristics

Waveland Lake is located approximately two miles northwest of Waveland Indiana. Although most of the lake is located in Montgomery County, a portion of the western shore is located in Parke County. The lake covers about 383 acres at normal pool level, has a gross storage capacity of about 1,198 million gallons of water, and has a watershed of about 11.3 square miles. The watershed is predominantly in agricultural use, and is entirely rural. The lake was created in 1970 by the Little Raccoon Conservancy District in cooperation with the Soil Conservation Service. There is a lakeside residential development along a portion of the northwest shore in Parke County.

WW Engineering and Science completed a feasibility study on Waveland Lake in 1989. The study found that Waveland Lake had a Eutrophication Index of 52 points, which places it in the category of Indiana lakes with the lowest water quality and highest eutrophication. They concluded that the sediment and nutrient inputs to the lake appeared to be the result of agricultural practices in the watershed. The study recommended implementing a series of land treatment measures for farmland in the watershed in order to reduce the flow of sediment and nutrients into the lake (Keith, 1991). At the time of the study, Waveland Lake was dominated by bluegreen algae and had relatively low Secchi readings. However, it appears that Waveland Lake is now dominated by submersed macrophytes and has improved Secchi disc readings. This may be due to a combination of improved land practices and a fish renovation which removed abundant common carp and gizzard shad.

Aquatic Control completed some basic water quality testing prior to the plant survey. A desirable dissolved oxygen level was present to a depth of 8 feet. The lake appeared to be stratified at the time of sampling. The pH was 8.3 and alkalinity was 102.6. Ortho-phoshorus was measured at 0.01 mg/l and nitrate was measured at 0.01 mg/l.

Waveland Lake has a watershed that is conducive to siltation and high phosphorus loading. This can lead to nuisance algae blooms, increased shallow areas, and an overall degradation of water quality. Typically, as watersheds are improved, water clarity will increase. This in turn will increase light penetration and allow for vegetation to grow in deeper water. Submersed vegetation obtains the majority of necessary nutrients from the sediment. Sediment in this area contains sufficient nutrients for plant growth. Based upon Aquatic Control's observations over the last thirty-nine years, we believe aquatic plants are not significantly limited by available phosphorus present in the water column. The University of Florida recently conducted a study comparing the amount of available nutrients to plant growth. They sampled aquatic plant in 319 lakes between 1983 and 1999 and found no significant correlation between nutrients in lake water and the abundance of rooted aquatic plants (Bachman et. al., 2002).

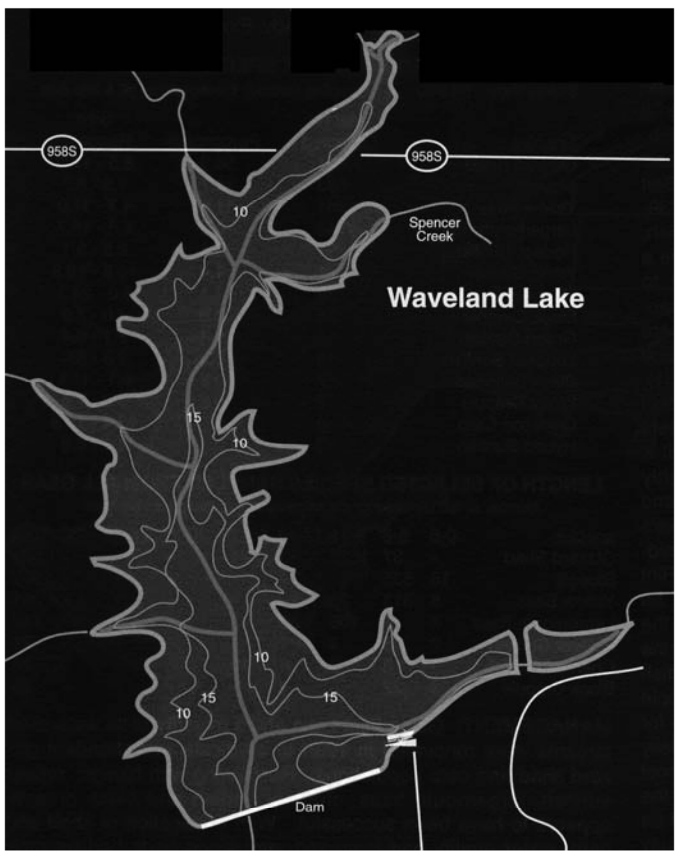



Figure 1. Bathymetric Map of Waveland Lake (Bright Spot Maps, 1996)

## Fisheries

Fish surveys have been completed on Waveland Lake in 1972, 1973, 1975, 1976, 1978, 1982, 1984, 1988, 1990, 1994, 1996, 1998, and 2003. The latest documented fish survey on Waveland Lake was completed on September 8 and 9, 2003 by the Indiana

Department of Natural Resources. This survey was conducted following a 2002 fish eradication treatment that was completed in an attempt to rid the lake of gizzard shad (*Dorsoma cepedianum)* and common carp (*Cyprinus carpio)*. Sampling effort consisted of 30 minutes of elecrofishing during the day, 30 minutes of night electrofishing, and six experimental mesh gill net lifts. A total of 661 fish and 5 species were collected. Largemouth bass (*Micropterus salmoides)* was the most abundant species collected. Despite being the primary target of the lake renovation, gizzard shad were found in large numbers and ranked second in abundance. Bluegill *(Lepomis macrochirus)*, channel catfish *(Ictalurus punctatus)*, and black bullhead *(Ameiurus melas)* comprised the remaining species collected (Table 1). Keller concluded that largemouth bass and channel catfish stockings appeared very successful. However, bluegill and redear stocking were not so successful. Growth rates of all species were good which is typical of a renovated population. The main concern was the presence of gizzard shad. A low-dose rotenone treatment is scheduled for the spring of 2005 in an attempt to eradicate or at least control gizzard shad (Keller, 2003). Muskie were stocked in the fall of 2004 in order to provide an additional sport fish and aid in the control of gizzard shad.

**Table 1. Species and Relative Abundance of Fishes Collected by Number and Weight (Keller, 2003).**

| Common Name | Number | Percent | Length Range | Weight | Percent |
|---|---|---|---|---|---|
| Largemouth Bass | 309 | 46.7 | 4.0-14.4 | 49.06 | 29.1 |
| Gizzard Shad | 172 | 26.0 | 8.4-10.3 | 53.07 | 31.4 |
| Bluegill | 104 | 15.7 | 0.8-7.4 | 12.14 | 7.2 |
| Channel Catfish | 73 | 11.0 | 8.9-24.6 | 52.77 | 31.3 |
| Black Bullhead | 3 | 0.5 | 8.9-10.4 | 1.72 | 1.0 |

**Present Water Body Uses**

Waveland Lake is a popular fishing, swimming, and water skiing lake. A public boat ramp, operated by the Waveland Parks Department, is located in the southeast corner of the lake. Just north of the boat ramp is a camping area which includes a public beach and boat marina. Residential housing is located in one cove in the northwest corner of the lake (Figure 2). These residents were present at a recent public meeting and voiced their concern over boat access to the lake that is being limited by aquatic vegetation. Concern was also raised about the danger submersed vegetation poses to swimmers. There is no boat motor restriction on Waveland Lake.

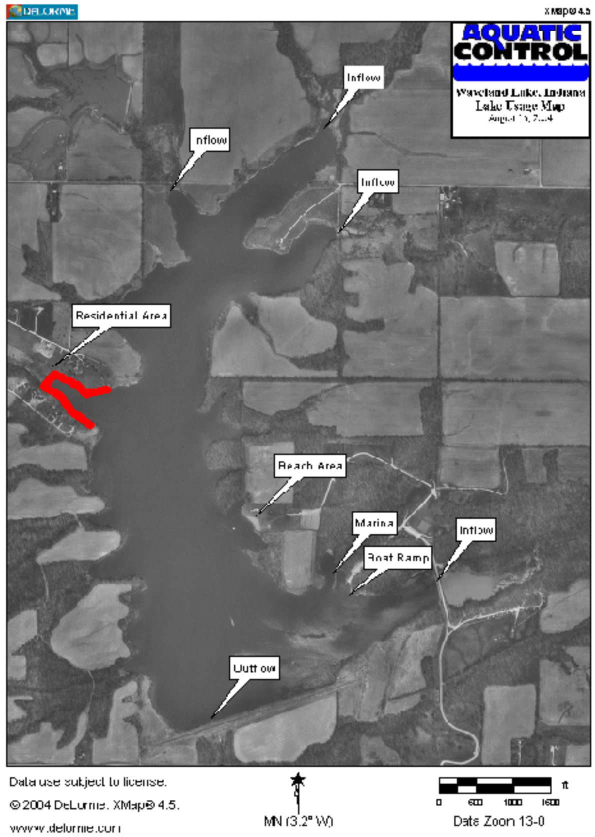



Figure 2. Lake Usage Map (not to scale see appendix)

## Aquatic Plant Community

There is limited data on past aquatic vegetation sampling. A brief survey was conducted by IDNR fisheries biologist during the 1998 fisheries sampling. Five species were documented during this sampling: common cattail (*Typhia latifolia)*, phragmites, filamentous algae, leafy pondweed (*Potamogeton foliosus*), and American pondweed (*Potamogeton nodosus*) (Wisener, 1998).

Tier I and Tier II sampling was completed on Waveland Lake on August 16, 2004. Ideally, two Tier II surveys should be completed in a season to document changes in the plant community that occur over the course of spring through late summer seasons, but due to time limitations a single survey was completed in 2004.

*Tier I survey*

The Tier I survey was developed to serve as a qualitative surveying mechanism for aquatic plants. The Tier 1 survey is based upon the procedure manual developed by Shuler & Hoffmann, 2002. This survey will serve to meet the following objectives:

1. to provide a distribution map of the aquatic plant species within a waterbody
2. to document gross changes in the extent of a particular plant bed or the relative abundance of a species within a waterbody (IDNR, 2004)

The Tier 1 survey revealed five distinct plant beds within Waveland Lake totaling 143 acres (Table 2 and Figure 3). Nine different species were observed during the Tier I sampling. Eurasian watermilfoil and curlyleaf pondweed were the only exotic species observed.

**Table 2. Tier I Survey Results (Rating of 1 is lowest abundance 4 is highest).**

| Plant Bed I.D. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Plant Bed Size (acres) | 46.03 | 60.55 | 6.82 | 27.39 | 2.17 |
| | Rating* | Rating* | Rating* | Rating* | Rating* |
| Southern naiad | 3 | 3 | 1 | 2 | 2 |
| Small pondweed | 3 | 2 | 2 | 2 | 2 |
| Sago pondweed | 2 | 2 | 2 | 3 | 2 |
| American pondweed | 2 | 4 | 3 | 3 | 2 |
| Brittle naiad | 2 | 2 | 2 | 2 | 1 |
| Coontail | 1 | 2 | 3 | 2 | 2 |
| Eurasian watermilfoil | 1 | - | - | - | - |
| Curlyleaf pondweed | - | 1 | - | - | - |
| Chara | - | - | - | 2 | 2 |

*rating is score from 1-4 with 1 being least dense and 4 being most dense

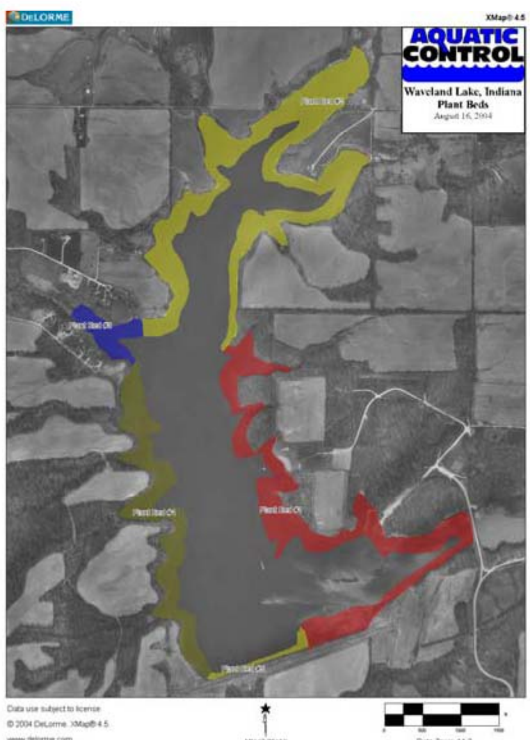



Figure 3. Tier I Plant Beds, Waveland Lake, August 20, 2004 (not to scale see appendix)

Plant bed 1 included the littoral area from the dam north past the public beach (Figure 3). This plant bed was determined to be 46.03 acres. The substrate of plant bed 1 was silt/clay. A total of 7 species were observed within the plant bed. Small pondweed, sago pondweed (*Potamogeton pusillus*), and southern naiad (*Najas guadalupensis*) were the dominant plant species (21-60% abundance rating). Brittle naiad *(Najas minor)* and American pondweed were found at 2-20% abundance. Eurasian watermilfoil and coontail were present at less than 2% abundance.

Plant bed 2 was located just north of plant bed 1 and included the majority of the upper end of Waveland Lake (Figure 3). Plant bed 2 was determined to be 60.55 acres. The substrate of plant bed 2 was silt/clay. A total of 7 species were observed within the plant bed. American pondweed was the dominant species (>60%) followed by southern naiad (21-60%). Sago pondweed (*Potamogeton pectinatus*), coontail, and small pondweed were present at 2-20% abundance. Brittle naiad and curlyleaf pondweed were also observed (<2%).

Plant bed 3 was located south of plant bed 2 (Figure 3). The shoreline of this area is the only part of Waveland Lake which is developed with residential housing. Plant bed 3 was determined to be 6.82 acres. The substrate of plant bed 3 was silt/clay. A total of 6 species were observed within the plant bed. Coontail and American pondweed were the most abundant species (21-60%). Sago pondweed, small pondweed, and brittle naiad were present at 2-20% abundance. Southern naiad was also observed in this area (<2%).

Plant bed 4 was located south of plant bed 3 and included the littoral region down to the dam (Figure 3). This plant bed was determined to be 27.39 acres. The substrate of plant bed 4 was silt/clay. A total of 7 species were observed within the plant bed. Sago and American pondweed were the most abundant species (21-60%). Brittle naiad, southern naiad, coontail, small pondweed, and chara were present at 2-20% abundance.

Plant bed 5 was located east of plant bed 4 and included the majority of the littoral zone along the dam (Figure 3). This plant bed was determined to 2.17 acres. The substrate of plant bed 5 was silt/clay. A total of 7 species were observed within the plant bed. Coontail was the most abundant species (21-60%). Southern naiad, sago pondweed, small pondweed, American pondweed, and chara were present at 2-20% abundance. Brittle naiad was also observed in this area (<2%).

*Tier II Survey*

Creation of the aquatic vegetation management plan also requires sampling to quantify the occurrence, distribution, and abundance aquatic vegetation. This type of survey will be referred to as the Tier II survey. This protocol is currently being used by the IDNR Division of Fish and Wildlife to provide a quantitative sampling mechanism for aquatic plant surveying. This protocol supplements the Tier I Reconnaissance Protocol for plant bed mapping. Together the protocols should serve to meet the following objectives:

1. to document the distribution and abundance of submersed and floating-leaved aquatic vegetation
2. to compare present distribution and abundance with past distribution and abundance within select areas (IDNR, 2004).

All of the data which was collected through the use of this protocol was recorded on standardized data sheets. The data collected was compared to data collected by district fisheries biologist Jed Pearson, which is presented in his 2004 paper "A Proposed Sampling Method to Assess Occurrence, Abundance, and Distribution of Submersed Aquatic Plants in Indiana Lakes". In this paper, Pearson used 21 northern Indiana lakes to calculate various aquatic plant abundance and diversity metrics (Pearson, 2004). We used the same sampling procedure outlined in Pearson's paper to calculate these same metrics for Waveland Lake. The data collected will also be valuable for future comparison, which will document changes in the plant community following proposed management activities.

Sample sites were randomly selected within the littoral zone of Waveland Lake (the number of sample sites is based upon lake's surface area). Once a site was reached the boat was slowed to a stop and the coordinates were recorded on a hand-held GPS unit and later downloaded into a mapping program. A depth measurement was taken by dropping a two-headed standard sampling rake that was attached to a rope marked off in 1-foot increments (Figure 4). An additional ten feet of rope was released and the boat was reversed at minimum operating speed for a distance of ten feet. Once the rake is retrieved the overall plant abundance on the rake is scored from 1-5 and then individual species are placed back on the rake and scored separately (the rake is marked off in 5 equal section on the tines, a score of 1 is lowest abundance and 5 is highest).

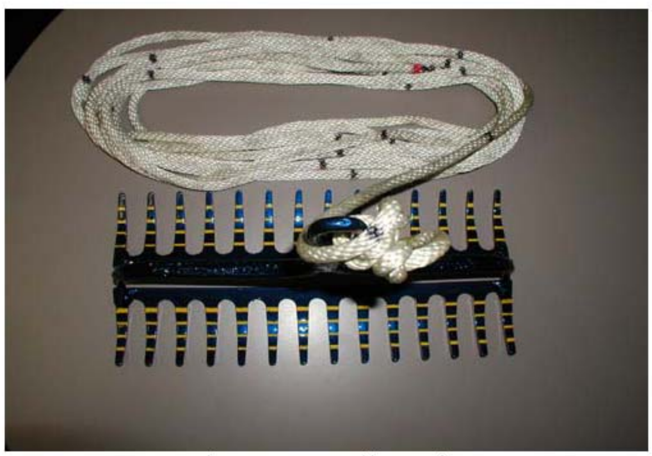


Figure 4. Sampling Rake

Tier II sampling took place on August 16, 2004 immediately following the Tier I sampling. Sixty-six sites were randomly sampled throughout the littoral zone (Figure 5). A Secchi disk reading was taken prior to sampling and was found to be 4.5 feet. Plants were present to a maximum depth of 8 feet. The mean depth from which samples were taken was 4.95 feet. The mean rake density score for Waveland Lake was 4.02. Species richness (average number of species per site) was 1.82 for all species and 1.78 for natives only. Site species diversity index was 0.79 for all species and 0.78 for native species only. Waveland Lake had a rake diversity score of 0.75 for all species and 0.74 for natives only. Overall aquatic vegetation distribution and abundance is illustrated in Figure 6. Compared to Pearson's 2003 data, it appears that Waveland Lake has a dense and somewhat diverse native plant population (Table 3).

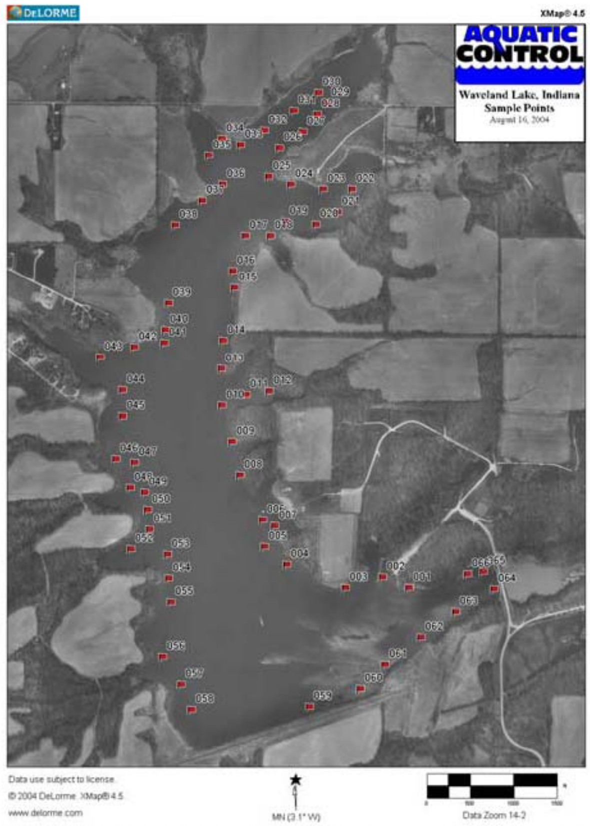



Figure 5. Tier II Sample Points (not to scale see appendix)

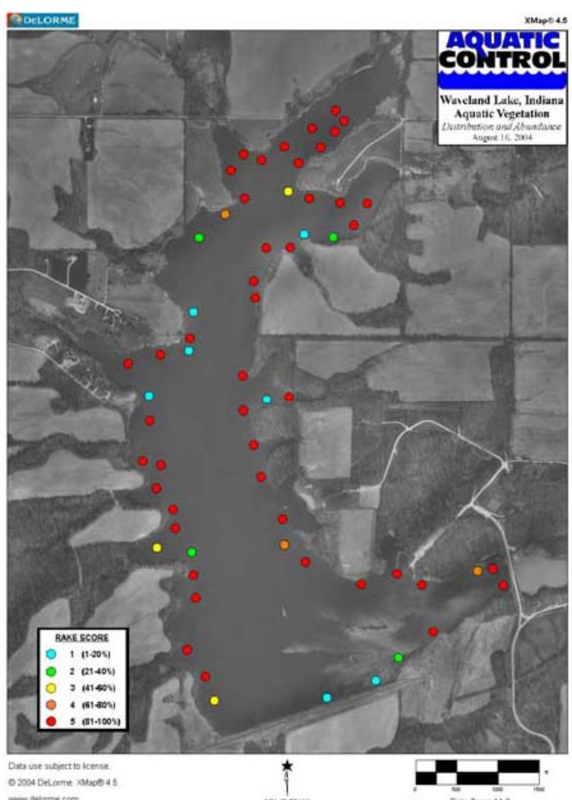



Figure 6. Aquatic vegetation distribution and abundance (not to scale see appendix)

**Table 3. Waveland Lake vegetation abundance, density, and diversity metrics compared to average**

| | Waveland Lake* | Average** |
|---|---|---|
| Percent of littoral zone sites with plants | 94% | - |
| # of species collected | 7 | 8 |
| # of native species collected | 6 | 7 |
| Mean Rake Density | 4.02 | 3.30 |
| Rake Diversity (SDI) | 0.75 | 0.62 |
| Native Rake Diversity (SDI) | 0.74 | 0.50 |
| Species Richness (Avg # spec./site) | 1.82 | 1.61 |
| Native Species Richness | 1.78 | 1.33 |
| Site Species Diversity | 0.79 | 0.66 |
| Site Species native diversity | 0.78 | 0.56 |

*standard deviation not included
**average calculated from Pearson Data.

Tier II sampling made it possible to map individual species location and density. A total of 7 species were collected of which 6 of the species were natives (Table 4). Curlyleaf pondweed was the only exotic species collected. Coontail was present in the highest percentage of sample sites (49.2%) (Figure 7), followed by southern naiad (46.2%) (Figure 8), American pondweed (41.5%) (Figure 9), sago pondweed (21.5%) (Figure 10), small pondweed (16.9%) (Figure 11), curlyleaf pondweed (3.1%) (Figure 12), and chara (3.1%) (Figure 13). It appears that Waveland Lake has a relative dense population of native vegetation.

**Table 4. Species collected during Tier II sampling.**

| Common Name | Scientific Name | Frequency of Occurrence | Relative Density | Dominance* Index |
|---|---|---|---|---|
| Coontail | *Ceratophyllum demersum* | 49.2% | 1.37 | 27.4% |
| Southern naiad | *Najas guadalupensis* | 46.2% | 1.23 | 24.6% |
| American pondweed | *Pomagoteton nodosus* | 41.5% | 1.32 | 26.5% |
| Sago pondweed | *Potamogeton pectinatus* | 21.5% | 0.32 | 6.5% |
| Small pondweed | *Potamogeton pusillus* | 16.9% | 0.23 | 4.6% |
| Curlyleaf pondweed | *Potamogeton crispus* | 3.1% | 0.03 | 0.6% |
| Chara | *Chara sp.* | 3.1% | 0.08 | 1.5% |

*Dominance Index is the percent of maximum abundance

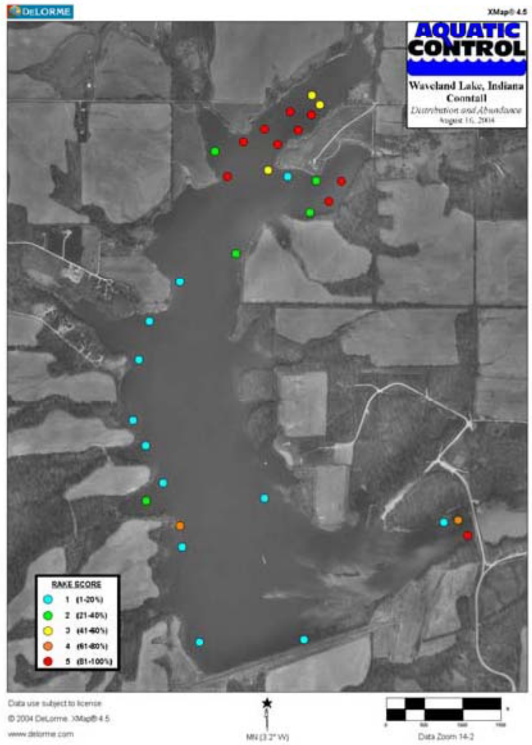



Figure 7. Coontail distribution and abundance (not to scale see appendix)

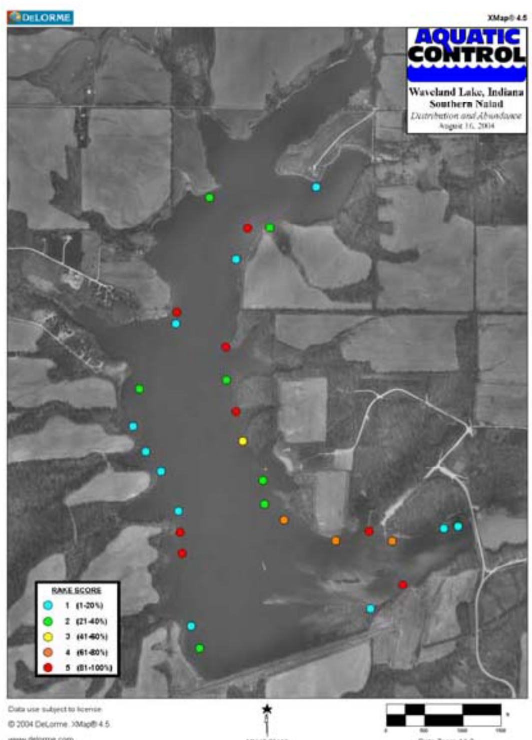



Figure 8. Southern naiad distribution and abundance (not to scale see appendix)

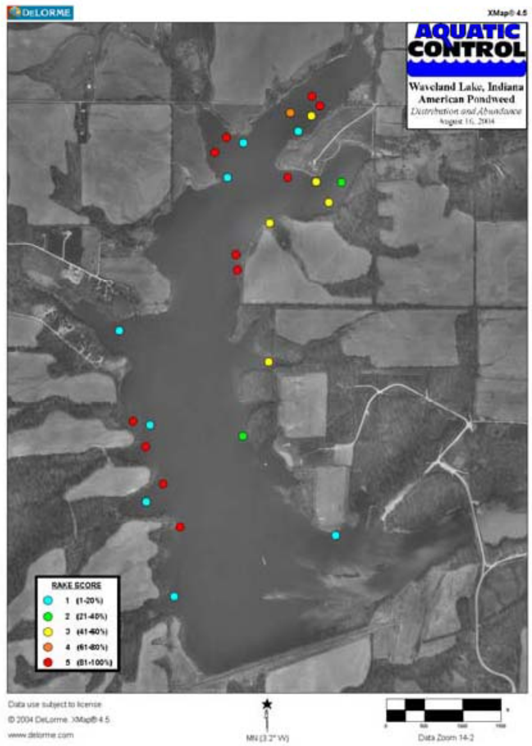



Figure 9. American pondweed distribution and abundance (not to scale see appendix)

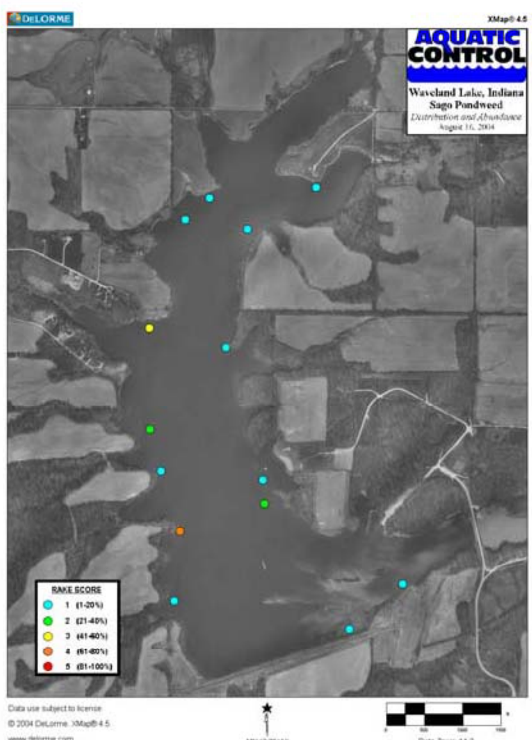



Figure 10. Sago pondweed distribution and abundance (not to scale see appendix)

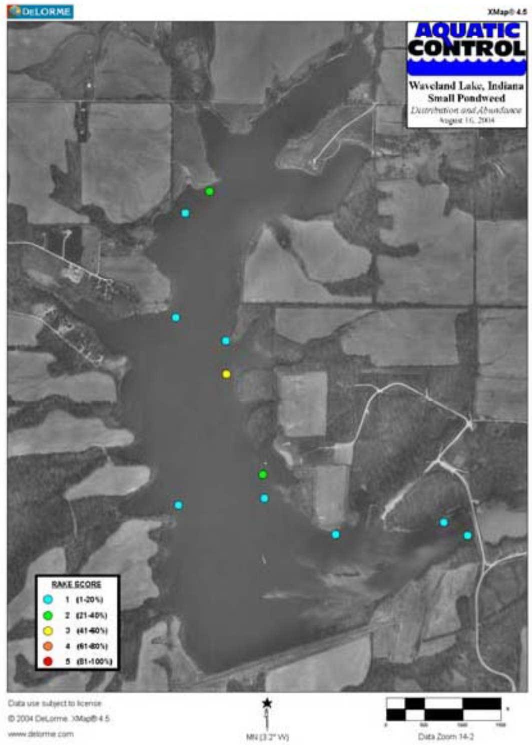



Figure 11. Small pondweed distribution and abundance (not to scale see appendix)

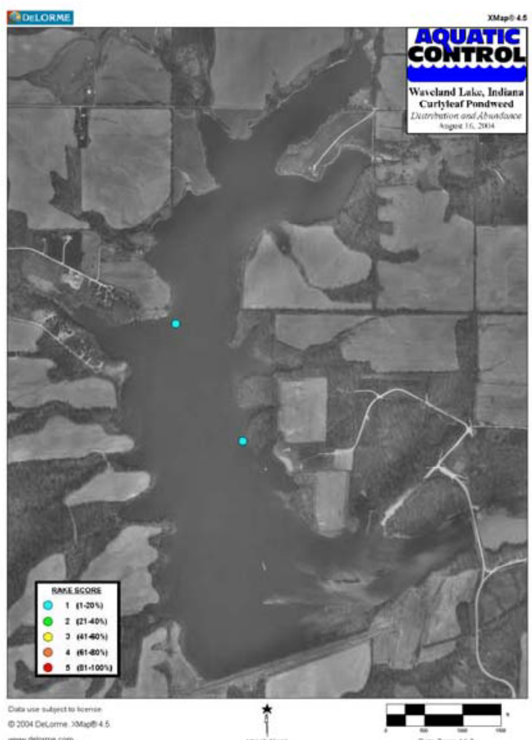



Figure 12. Curlyleaf pondweed distribution and abundance (not to scale see appendix)

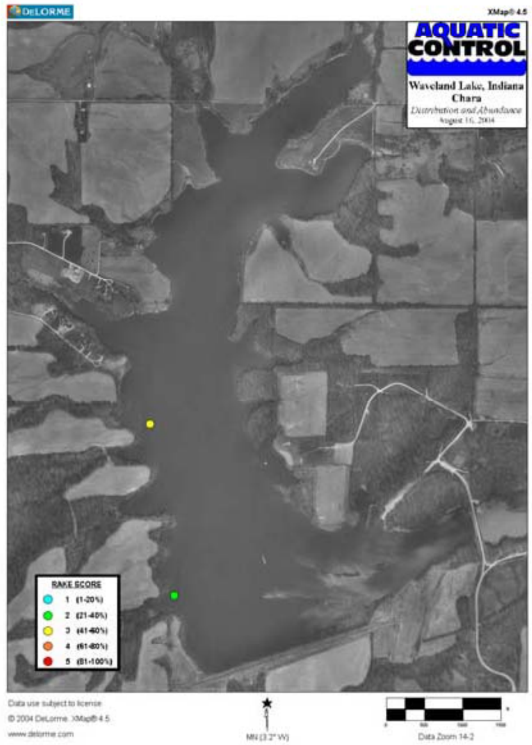



Figure 13. Chara distribution and abundance (not to scale see appendix)

### Plant Management History

There is no record of any plant management activity which has taken place on Waveland Lake. Prior to the fish eradication treatments Waveland Lake contained very turbid water which limited plant growth and the need for plant management. After the elimination of common carp there has been a dramatic increase in water clarity thus an increase in the need for aquatic plant management.

### Aquatic Plant Management Alternatives

The main nuisance aquatic vegetation within Waveland Lake at the time of the survey were native species, predominantly coontail. However, these species were only creating nuisance conditions in high use areas. There remained a large percentage of open water for water skiing, swimming, and fishing. The exotic species curlyleaf pondweed was sampled at only two sites. This species typically reaches maximum density during spring and early summer. Curlyleaf pondweed can cause nuisance conditions and should be monitored next spring.

Eurasian watermilfoil was not collected during the Tier II survey, but was observed during the Tier I survey. This species should be closely monitored and controlled following a spring survey in order to prevent it from spreading throughout the lake competing with native vegetation and causing nuisance conditions. It is believed that Eurasian watermilfoil was first introduced from Eurasia or North Africa to an area near Maryland around 1942, possibly through the aquarium trade. Some reports suggest that this species may have been introduced into North America as early as the late 1800's through shipping ballast (Ditomaso & Healy, 2003). This species has now spread throughout the majority of North America and is the primary nuisance submersed aquatic species in Indiana. Once established, growth and physiological characteristics of Eurasian watermilfoil enable it to form a surface canopy and develop into immense stands of weedy vegetation, out competing most submersed species and displacing the native plant community (Madsen et al., 1988). Eurasian watermilfoil can also have negative impacts on fish populations.

In order to develop a scientifically sound and effective action plan, all aquatic management alternatives need to be considered. The alternatives that will be discussed include: no action; environmental manipulation; chemical, mechanical, or biological control methods; and any combination of these methods.

A number of different techniques have been successfully used to control nuisance submersed vegetation. These techniques vary in terms of their efficacy, rapidity, and selectivity, as well as the thoroughness and longevity of control they are capable of achieving. Each technique has advantages and disadvantages, depending on the circumstances. Selectivity is a particularly important characteristic of control techniques. Nearly all aquatic plant control techniques are at least somewhat selective, in that they affect some plant species more than others. Even techniques such as harvesting that have little selectivity within the areas to which they are applied can be used selectively, by choosing only certain areas in which to apply them. Selectivity can also occur after the fact, as when a technique controls all plants equally but some grow back more rapidly. One facet of selecting an appropriate aquatic plant control technique is matching the selectivity of the control technique with the goals of aquatic plant management. When controlling Eurasian watermilfoil, for example, it is typically desirable to use techniques that control Eurasian watermilfoil with minimal impact on most native species (Smith, 2002).

*No Action*

What if no aquatic plant management activity took place on Waveland Lake? To our knowledge, this has been the case since the creation of Waveland Lake. Nuisance conditions would continue to hamper boating, swimming, and fishing activities in high-use areas. Eurasian watermilfoil would most likely spread and displace native vegetation. This species could also increase nuisance conditions to other areas in the lake.

*Environment manipulation*

Environmental manipulation for Waveland Lake would include water level drawdown. Drawdown is usually conducted in the winter months so that plants are exposed to both drying and freezing. This method effects species differently and is highly variable depending on the amount of freezing and thawing which occurs. Drawdown will likely take place in the winter of 2005 in preparation for a low dose rotenone treatment for control of gizzard shad. This may give some relief to nuisance conditions. If this drawdown effectively reduces nuisance conditions this technique should be considered for future action plans.

*Mechanical*
Mechanical control includes cutting, dredging, or tilling the bottom sediments to eliminate aquatic plant growth. The main advantage to mechanical control is the immediate removal of the plant growth from control areas and the removal of organic matter and nutrients.

One of the most common mechanical control techniques used on larger lakes in Indiana is mechanical harvesting. Mechanical harvesting uses machines which cut plant stems and, in most cases, pick up the cut fragments for disposal. This type of mechanical control has little selectivity. Where a mix of Eurasian watermilfoil and native species exists, harvesting favors the plant species that grow back most rapidly following harvesting. In most cases, Eurasian watermilfoil recovers from harvesting much more rapidly than native plants. Thus, repeated harvesting hastens the replacement of native species by Eurasian watermilfoil and often leads to dense monocultures of Eurasian watermilfoil in frequently harvested areas. Harvesting also stirs up bottom sediments thus reducing water clarity, kills fish and many invertebrates, and hastens the spread of Eurasian watermilfoil via fragmentation. For these reasons, harvesting is not recommended as a primary control method. However, this method could be used on a small scale to remove vegetation which is interfering with docks or swimming areas.

*Biological*
Biological controls reduce aquatic vegetation using other organisms that consume aquatic plants or cause them to become diseased (Smith, 2002). The main biological controls for aquatic vegetation used in Indiana are the white amur (grass carp). The milfoil weevil has been used in an attempt to control Eurasian watermilfoil.

The white amur or grass carp *Ctenopharyngodon idella* is a herbivorous fish imported from Asia. Triploid grass carp, the sterile genetic derivative of the diploid grass carp, are legal for sale in Indiana. Grass carp tend to produce all or nothing aquatic plant control. It is very difficult to achieve a stocking rate sufficient to selectively control nuisance species without eliminating all submersed vegetation. They are not particularly appropriate for Eurasian watermilfoil control because Eurasian watermilfoil is low on their feeding preference list; thus, they eat most native plants before consuming Eurasian watermilfoil (Smith, 2002). Grass carp are also difficult to remove from a lake once they have been stocked. Grass carp are not recommended for vegetation control in Waveland Lake.

The milfoil weevil, *Euhrychiopsis lecontei,* is a native North American insect that consumes Eurasian and Northern watermilfoil. The weevil was discovered following a natural decline of Eurasian watermilfoil in Brownignton Pond, Vermont (Creed and Sheldon, 1993), and has apparently caused declines in several other water bodies. Weevil larvae burrow in the stem of Eurasian watermilfoil and consume the vascular tissue thus interrupting the flow of sugars and other materials between the upper an lower parts of the plant. Holes where the larvae burrow into and out of the stem allow disease organisms a foothold in the plants and allow gases to escape from the stem, causing the plants to lose buoyancy and sink (Creed et al. 1992).

Concerns about the use of the weevil as a biological control agent relate to whether introductions of the milfoil weevil will reliably produce reductions in Eurasian watermilfoil and whether the resulting reductions will be sufficient to satisfy users of the lake (Smith, 2002). Following our research, no conclusive data concerning the role of weevils in reducing Eurasian watermilfoil populations has been made available. In 2003, Scribailo & Alix conducted a weevil release study on three Indiana lakes and had no conclusive evidence supporting the use of weevils in reducing milfoil populations. Weevils may reduce milfoil populations in some lakes, but predicting which lakes and how much, if any, control will be achieved has not been documented.

*Chemical Control*

Chemical control uses chemical herbicides to reduce or eliminate aquatic plant growth. The main advantage of using herbicides is their overall effectiveness. The publics main concern over herbicide use is safety. This should not be a concern due to the extensive testing which is required prior to herbicide being approved for use in the aquatic environment. These tests ensure that the herbicides are low in toxicity to human and animal life and they are not overly persistent or bioaccumulated in fish or other organisms.

There are two different types of aquatic herbicides; systemic and contact. Systemic herbicides are translocated throughout the plants and thereby kill the entire plants. Fluridone (trade name Sonar & Avast!) can effectively control most aquatic plant species, and at the correct rate fluridone can selectively control Eurasian watermilfoil. 2,4-D (trade name Navigate, Aqua-Kleen, & DMA4 IVM), and trichlopyr (trade name Renovate) are systemic herbicides that can effectively control Eurasian watermilfoil.

Based upon the author's experience and personal communication with a vast array of North American aquatic plant managers, whole-lake fluridone applications are by far the most effective means of controlling Eurasian watermilfoil. Successful fluridone treatments yield a dramatic reduction in the abundance of Eurasian watermilfoil, often reducing it to the point that Eurasian watermilfoil plants are difficult to detect following treatment (Smith, 2002). An advantage to using fluridone over most contact herbicides is its selectivity. Most strains of Eurasian watermilfoil have a lower tolerance to fluridone than the majority of native species, so if the proper rates are applied Eurasian water milfoil can be controlled with little harm to the majority of native species. The disadvantage to a whole lake fluridone treatment is the one-time cost. This type of treatment is not necessary on Waveland Lake due to the limited amount of Eurasian watermilfoil which appears to be isolated in one area.

Triclopyr is a systemic herbicide that has recently been approved for use in aquatics. Triclopyr typically is used for treating isolated milfoil beds as opposed to whole lake treatments. This herbicide is very selective to Eurasian watermilfoil. Getsinger, Turner, Madsen, and Netherland studied the effects of Triclopyr in a paper titled "Restoring Native Vegetation in a Eurasian Watermilfoil Dominated Plant Community Using the Herbicide Triclopyr." They found Eurasian watermilfoil biomass was reduced by 99% in treated areas at 4 weeks post-treatment, remained low one year later, and was still at acceptable levels of control at two years post-treatment. Non-target native plant biomass increased 500-1000% by one year post-treatment, and remained significantly higher in the cove plot at two years post-treatment. Native species diversity doubled following herbicide treatment, and the restoration of the community delayed the re-establishment and dominance of Eurasian watermilfoil for three growing season. Triclopyr is a good alternative to fluridone when Eurasian watermilfoil is not abundant throughout an entire water body.

Applied properly, 2,4-D can also yield major reductions in the abundance of Eurasian watermilfoil, but long-term reductions are more difficult to achieve using 2,4-D than using whole-lake fluridone applications. Treatments must be even and dose rates accurate. Under the best circumstances, some areas will probably need to be treated repeatedly before the Eurasian watermilfoil in them is controlled. Also, the difficulty of finding and treating areas of sparse Eurasian watermilfoil makes it likely that Eurasian watermilfoil will be reestablished from plants surviving in these areas (Smith 2002). This formulation should be used much like Triclopyr, but the same results may not occur. Unlike Triclopyr, 2,4-D can impact the native species coontail.

Contact herbicides can also be effective for controlling submersed vegetation in the short term. The three primary contact herbicides used for control of submersed vegetation are diquat (trade name Reward), endothal (trade name Aquathol), and copper based formulations (trade names Komeen, Nautique, and Clearigate).

Historically, a drawback to the use of contact herbicides has been the lack of selectivity exhibited by these herbicides. However, a study recently completed by Skogerboe and Getsinger outlines how endothal can be used for control of the exotic species curlyleaf pondweed and Eurasian watermilfoil with little effect on the majority of native species. They found early season treatments with endothall effectively controlled Eurasian watermilfoil and curlyleaf pondweed at several application rates with no regrowth eight weeks after treatment. Sago pondweed, eel grass, and Illinois pondweed biomass were also significantly reduced following the endothall application, but regrowth was observed at eight weeks post-treatment. Coontail and elodea showed no effects from endothall at three of the lower application rates. Spatterdock, pickerelweed, cattail, and smartweed were not injured at any of the application rates (Skogerboe & Getsinger 2002). This type of treatment strategy could be applied to lakes that have large areas of both curlyleaf pondweed and Eurasian watermilfoil. However, the one drawback to the use of endothal is a 3-day fish harvest restriction which is currently under review by U.S. E.P.A. This restriction may be removed in the next few years. Endothal could also be effective the year after whole lake fluridone treatments where curlyleaf pondweed typically returns the following season.

Diquat and many of copper formulations are effective fast acting contact herbicides. These formulations are typically used when control of all submersed vegetation is desired. Aquatic Control uses these herbicides for control of nuisance vegetation around docks and near-shore high-use areas. A drawback to the use of these herbicides is the lack of selectivity and quick recovery time of treated vegetation.

**Table 5. Advantages and Disadvantages of potential control methods.**

| Control Method | Advantages | Disadvantages | Conclusion |
|---|---|---|---|
| **No Action** | No cost, less controversy | No plant control, degradation of fish habitat, difficult boating, and spread of exotics plant species. | Something should be initiated to prevent spread of milfoil. |
| **Environmental Manipulation (drawdown)** | Low cost, compaction of flocculent sediments, may get control of some nuisance species, and less controversial. | Unpredictable plant control, exposes desirable plants and animals to freezing and thawing, dependent on good freeze, could impede recreation, dependent on spring rains to raise water level, and could lead to dissolved oxygen problems. | Has potential to be integrated with chemical control, but results are unpredictable. Need to further research feasibility of drawdown. |
| **Mechanical (cutting, dredging, or tilling)** | Low cost, less controversy, and one can target areas of desired control, removes organics. | Possibility of spreading exotic vegetation, labor intensive, damage to fish and other aquatic organisms, and harvesting can promote increased milfoil growth. | Not good option due to potential spread of exotics. Could possibly be used on small-scale initial infestation or post-treatment. |
| **Biological Control (milfoil weevil)** | No chemical needed, naturally occurring native species, no use restrictions following application, selective for Eurasian watermilfoil, and known to cause fatal damage to plant | Studies have been inconclusive on the effectiveness and cost is relatively high compared to most other control methods. Will not control curlyleaf pondweed. | No proof that this method is effective. Too large of an investment for unproven method. |
| **Biological Control (Grass Carp)** | No chemical needed, no use restrictions following application, and proven to consume aquatic vegetation. | Prefers many of the native species over exotic species, non-native fish species, tend to move downstream, once they are introduced they are nearly impossible to remove. | Not a good option due to inability to remove once stocked. |
| **Chemical Control** | Proven safe and effective technique, can be selective, relatively easy application, and fast results. | Higher cost than most techniques, public concern over chemicals, build-up of dead plant material following application, and lake use restrictions | Proven to be effective & minimal use restrictions very effective for curlyleaf pondweed and Eurasian watermilfoil control |

## Action Plan

The goal of the Waveland Lake Department of Parks and Recreation is to reduce the impact of submersed vegetation in high-use areas and to control and prevent the spread of exotic plant species.

Eurasian watermilfoil was found at only one location in Waveland Lake (Figure 14). Plant sampling should be initiated in the spring of 2005 in order to locate all areas of Eurasian watermilfoil. After these areas are located Eurasian watermilfoil should be treated with a systemic herbicide in order to control this species and prevent its spread. Waveland Lake could easily be overrun by this species if no action is taken in 2005.


Figure 14. Eurasian watermilfoil location, August 16, 2004

Concern has been raised over the interference caused by submersed native vegetation (public meeting, November 16, 2004). This vegetation has restricted boating, swimming, and fishing. A great deal of concern was voiced over swimmer safety (swimmers can become entangled in dense submersed vegetation). High-use areas should be managed in an effort to reduce the negative impacts of submersed vegetation. This will likely require two herbicide applications to these select areas on an annual basis. The areas slated for application are the beach area, marina area, boat launch area, and the cove which contains permanent residences. Endothal should be used for the spring treatment. Endothal is very effective at controlling the exotic species curlyleaf pondweed. It will also control the majority of other nuisance causing species in Waveland Lake. Diquat should be used in these areas in summer. This herbicide is a good short-term control for all pondweed species. Diquat is also much more effective at controlling southern naiad which had reached nuisance levels in some of the high use areas. Based on 2004 sampling, it is estimated that 7.5 acres of submersed vegetation should be treated in order to alleviate nuisance conditions. Exact acreages and herbicides should be determined following plant surveys which should be completed in the spring and late summer. In following years, the action plan may need adjusted as new, more effective herbicides become approved for aquatic use.

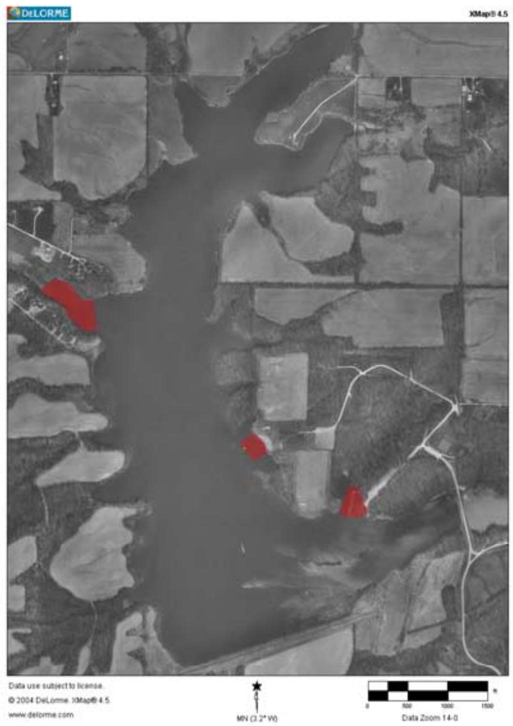



Figure 15. Potential 2004 contact treatment areas

One of the most important aspects of the action plan is the plant sampling. A Tier I and Tier II survey should be completed in May of 2005. Another Tier II survey should be completed in August. The spring survey will document the abundance and density of curlyleaf pondweed, which may be creating more problems than observed during the August sampling. This sampling will also allow the location of Eurasian watermilfoil to be documented prior to treatment. The August sampling will document the effects of plant management activities and help to determine changes which may be needed in 2006.

The initiation of this action plan will allow Eurasian watermilfoil to be controlled at a very early stage of invasion. Early treatment of this species should help save money in the long run and prevent Eurasian watermilfoil from negatively impacting native plant species and the fishery. This action plan will also allow for the control of nuisance species in high-use areas while leaving a healthy amount of native vegetation for fish cover.

**Table 6. Budget estimates for management options**

| | 2005 | 2006 | 2007 |
|---|---|---|---|
| Eurasian watermilfoil herbicide | $2,000 | $2,000 | $2,000 |
| Herbicide & Application Cost | $6,000 | $6,000 | $6,000 |
| Vegetation Sampling & Plan Update | $2,460 | $2,460 | $2,460 |
| **Total:** | **$10,460*** | **$10,460*** | **$10,460*** |

*Prices are based on 2004 herbicide costs. These prices may increase.

## Education

It is important that all lake users, lake residents, and other stakeholders participate and be informed about the lake management activities. A public meeting was conducted on November 16, 2004 in order to obtain user input concerning aquatic vegetation problems and action which could be initiated. Each winter a similar meeting should take place to discuss necessary changes in the plan and to update lake users of changes and activities. Information discussing aquatic vegetation management activities and treatment restrictions should be posted in high use areas around the lake. Signs should be posted at the boat ramp warning people about the dangers of transporting exotic vegetation. Additional information concerning aquatic vegetation management can be obtained at the following web sites: www.mapms.org www.aquatics.org www.apms.org, www.aquaticcontrol.com www.nalms.org .

## References

Applied Biochemists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.

Bachmann, R.W., Horsburgh, C.A., Hoyer, M.V., Mataraza, L.K., and Canfield, D.E. 2002. Relations between trophic state indicators and plant biomass in Florida lakes. Department of Fisheries and Aquatic Sciences, University of Florida. Hydrobiologia 470:219-234.

Bright Spot Maps. 1996. Kosciusko-Marshall-Fulton-Elkhart-St. Joseph Counties, 74 Lake Maps Featuring Contours and Depths. Laporte, IN

Chadde, Steve W. 1998. A Great Lakes Wetland Flora. Pockteflora Press, Calumet Michigan.

DiTomaso, J. M. and Healy, E. A. 2003. Aquatic and Riparian Weeds of the West. University of California Agriculture and Natural Resources. Oakland, CA.

Fassett, Norman C. 1968. A Manual of Aquatic Plants. The University of Wisconsin Press. Madison, WI.

Getsinger, K.D., Turner, E.G., Madsen, J.D., and Netherland, M.D. 1997. Restoring Native Vegetation in a Eurasian Water Milfoil-Dominated Plant Community Using The Herbicide Triclopyr. Regulated Rivers: Research & Management, Vol. 13, 357-375.

IDNR, 2004. Procedure Manual For Surveying Aquatic Vegetation: Tier I Reconnaissance Surveys. IN Department of Natural Resources, Division of Soil Conservation.

IDNR, 2004. Procedure Manual For Surveying Aquatic Vegetation: Tier II Reconnaissance Surveys. IN Department of Natural Resources, Division of Soil Conservation.

Keith, J. H. 1991. Feasibility study of Lake Waveland and its watershed Montgomery County and Parke County, Indiana. WW Engineering and Science. Bloomington,IN.

Keller, D. C. 2003. Lake Waveland 2003 Fish Management Report. Fisheries Section Indiana Department of Natural Resources. Division of Fish and Wildlife. Indianapolis, IN.

Keller, D. C. 2003. Lake Waveland Renovation Summary. Fisheries Section Indiana Department of Natural Resources. Division of Fish and Wildlife. Indianapolis, IN.

Maceina, M.J., Reeves, W.C., Wrenn, W.B., & Lowery, D.R. 1996. Relationships between Largemouth Bass and Aquatic Plants in Guntersville Reservoir, Alabama. American Fisheries Society Symposium 16:382-395. 1996.

Madsen, J.D., Sutherland, J.W., Bloomfield, J.A., Eichler, L.W., and Boylen, C.W. The decline of native vegetation under dense Eurasian watermilfoil canopies. Journal of Aquatic Plant Management., 29, 94-99.

Pearson, Jed. 2004. A sampling method to assess occurrence, abundance and distribution of submersed aquatic plants in Indiana lakes. IN Department of Natural Resources. Division of Fish & Wildlife. Indianapolis, IN.

Scribalio, R. W. and Alix, M.S. 2003. Final Report on the Weevil Release Study for Indiana Lakes. Department of Botany and Plant Pathology. Purdue University. West Lafayette, IN.

Skogerboe, J.G., & Getsinger, K.D. 2002. Endothall species selectivity evaluation: northern latitude aquatic plant community. J. Aquatic Plant Management. 40: 1-5.

Smith, C. S. 2002. Houghton Lake Management Feasibility Study. Prepared for the Houghton Lake Improvement Board. Remetrix LLC. Indianapolis, IN.

Winterringer, Glen S. & Lopinot, Alvin C. Aquatic Plants of Illinois. Department of Registration & Education, Illinois State Museum Division & Department of Conservation, Division of Fisheries. Springfield, IL.

Wisener, R. J. 1998. Waveland Lake 1998 Fish Management Report. Fisheries Section. Indiana Department of Natural Resources. Division of Fish and Wildlife. Indianapolis, IN.

## Appendix A. Macrophyte List for Waveland Lake

| Common Name | Scientific Name | Tier I Survey | Tier II Survey |
|---|---|---|---|
| American pondweed | *Potamogeton nodosus* | X | X |
| Brittle naiad | *Najas minor* | X | |
| Chara | *Chara sp.* | X | X |
| Coontail | *Ceratophyllum demersum* | X | X |
| Curlyleaf pondweed | *Potamogeton crispus* | X | X |
| Eurasian Watermilfoil | *Myriophyllum spicatum* | X | |
| Sago Pondweed | *Potamogeton pectinatus* | X | X |
| Small pondweed | *Potamogeton pusillus* | X | X |
| Southern naiad | *Najas guadalupensis* | X | X |

American pondweed (*Potamogeton nodosus*)is a submersed monocot which has floating leaves. Provides food for waterfowl and good fish cover. Typically inhabits near shore shallow areas. Rarely creates nuisance conditions.

Chara (*chara sp.)* is an anchored green algae with whorled, branchlike filaments at the nodes of a central axis. Often times mistaken for vascular plants. Typically inhabits shallow water. Provide food and cover for wildlife. Rarely reaches the surface of the water and rarely causes problem.

Coontail (*Ceratophylum demersum*) is a commonly occurring aquatic plant in the Midwest in neutral to alkaline waters[1]. It is a submersed dicot with coarsely toothed leaves whorled about the stem[2]. This plant is given its name due to its resemblance to the tail of a raccoon. Coontail has been found to be an important food source for wildfowl as well as a good shelter for small animals[2]. This plant is also a good shelter for young fish, and support of insects[2], but has been known to crowd out other species of aquatic plants[3].

Curlyleaf pondweed (*Potamogetan crispus*) is a submersed monocot with slightly clasping, rounded tip leaves. The flowers occur on dense cylindrical spikes and produces distinctive beaked fruit[1]. Curly leaf is eaten by ducks, but may become a weed[2]. This plant provides good food, shelter, and shade for fish and is important for early spawning fish like carp and goldfish[2].

Eurasian water-milfoil (*Myriophyllum spicatum*) is an exotic aquatic plant that has been known to crowd out native species of plants. This species spreads quickly because it can grow from very small plant fragments and survive in low light and nutrient conditions[3]. This dicot has stems that typically grow to the water surface and branch out forming a canopy that shades other species of aquatic plants. Eurasian water-milfoil has characteristic red to pink flowering spikes that protrude from the water surface one to two

---

[1] Chadde, S. 1998. Great lakes wetland flora. Pocketflora Press, Calumet, Michigan.
[2] Fassett, N. 1957. A manual of aquatic plants, 2nd edition. The University of Wisconsin Press, Madison, Wisconsin.
[3] Applied Biocehmists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.

inches high[1]. The segmented leaves grow in whorls of three to four around the stem[1]. This exotic plant is easily differentiated from its native relative, northern milfoil, by stem growth and the numbers of sections per leaf.

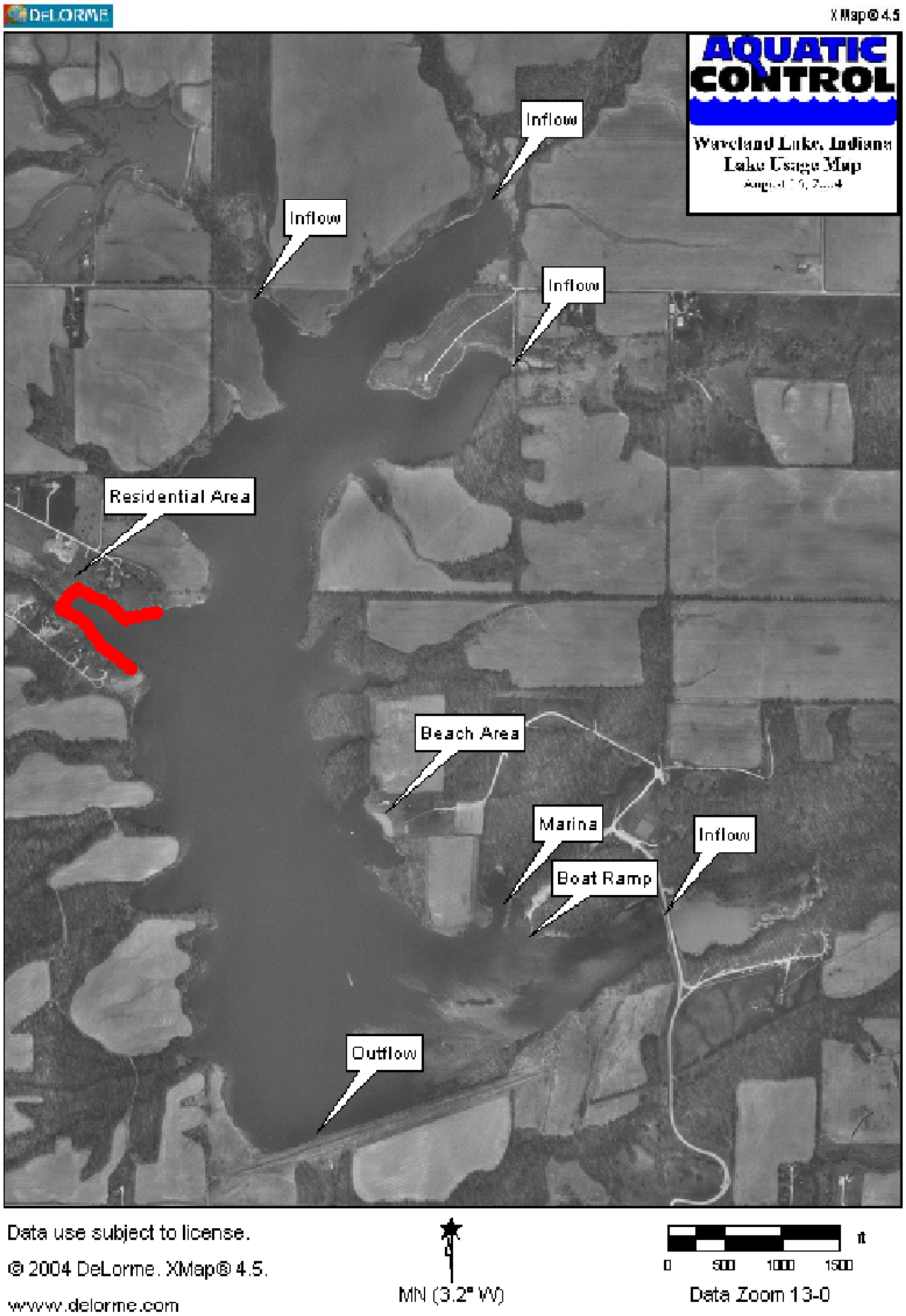
Sago pondweed (*Stuckenia pectinata*) is a submersed monocot with leaves that are threadlike to narrowly linear that form a sheath around the stem[1]. The nutlet and tubers of this plant make it the most important pondweed for ducks[2]. It also provides food and shelter for young trout and other fish[2]. This species can produce thick nuisance growth in shallow near-shore areas of lakes.

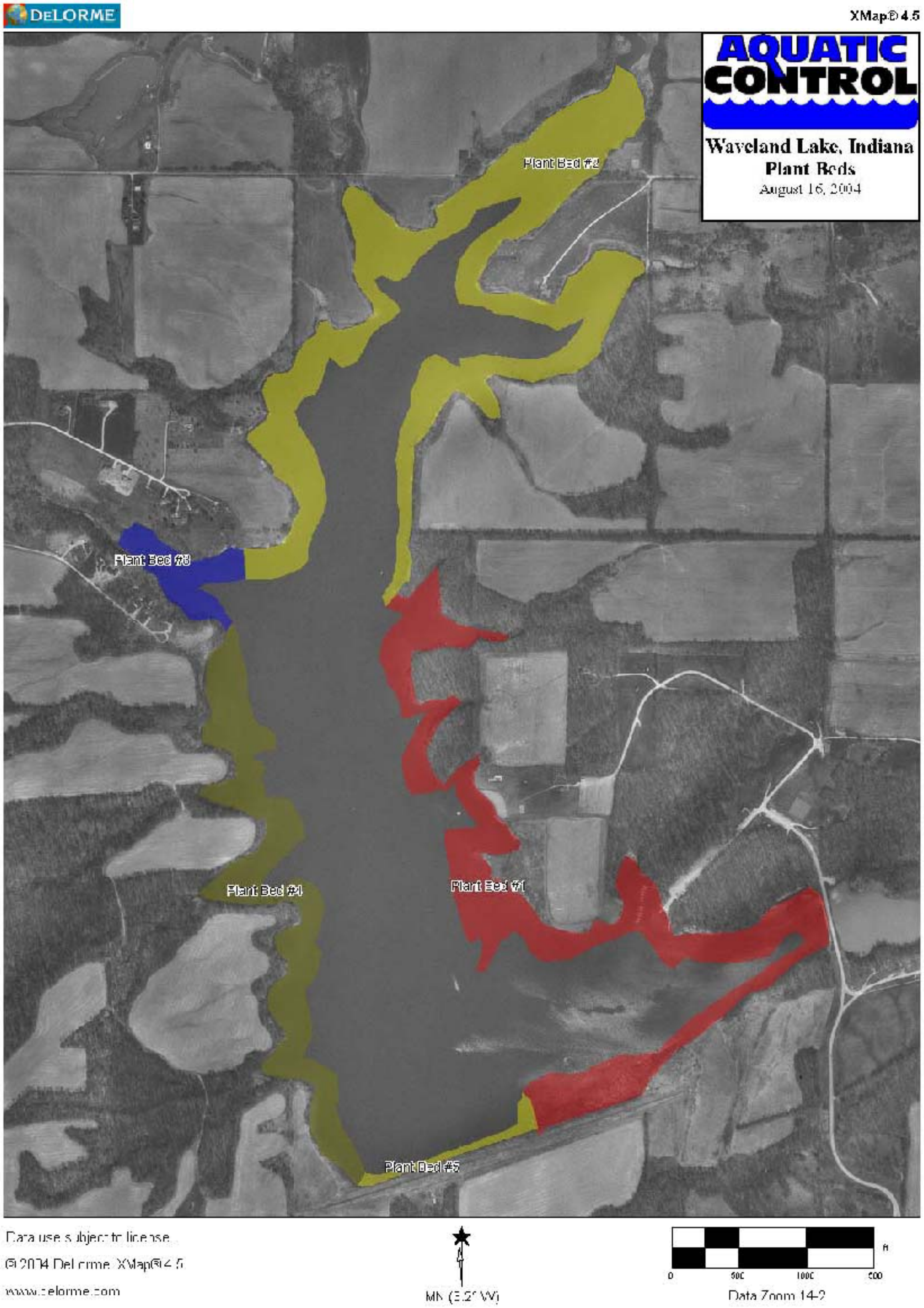
Small pondweed (*Potamogetan pusillus*) is a submersed monocot with slender, long leaves. Its fruit is green to brown and has a flat beak[1]. This plant provides fish with good cover and food and is a good food source for wildfowl[2]. This species has a propensity for developing nuisance conditions when competition from other species is not present.

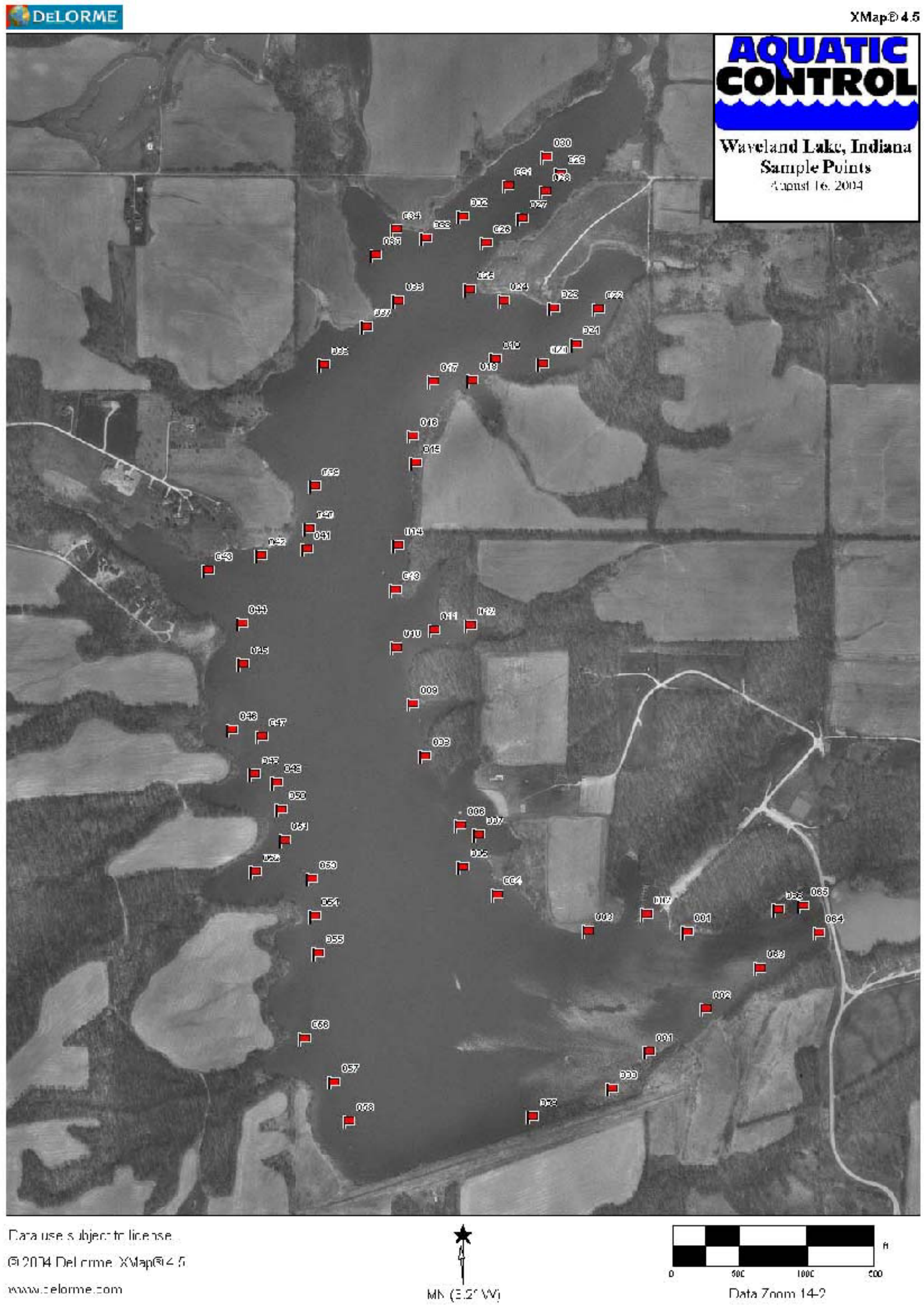
.

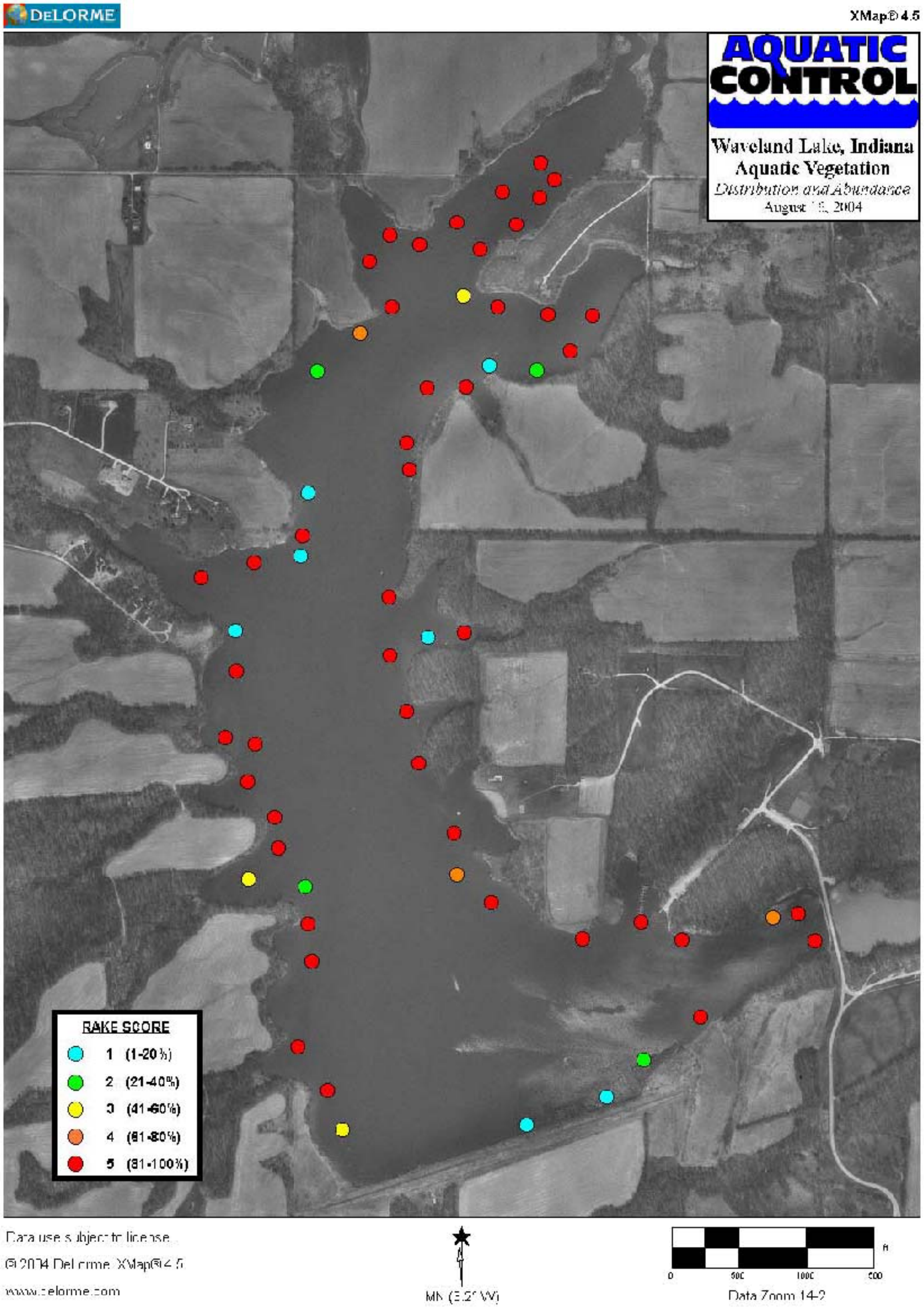
[1] Chadde, S. 1998. Great lakes wetland flora. Pocketflora Press, Calumet, Michigan.
[1] Fassett, N. 1957. A manual of aquatic plants, 2nd edition. The University of Wisconsin Press, Madison, Wisconsin.
[1] Applied Biocehmists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.

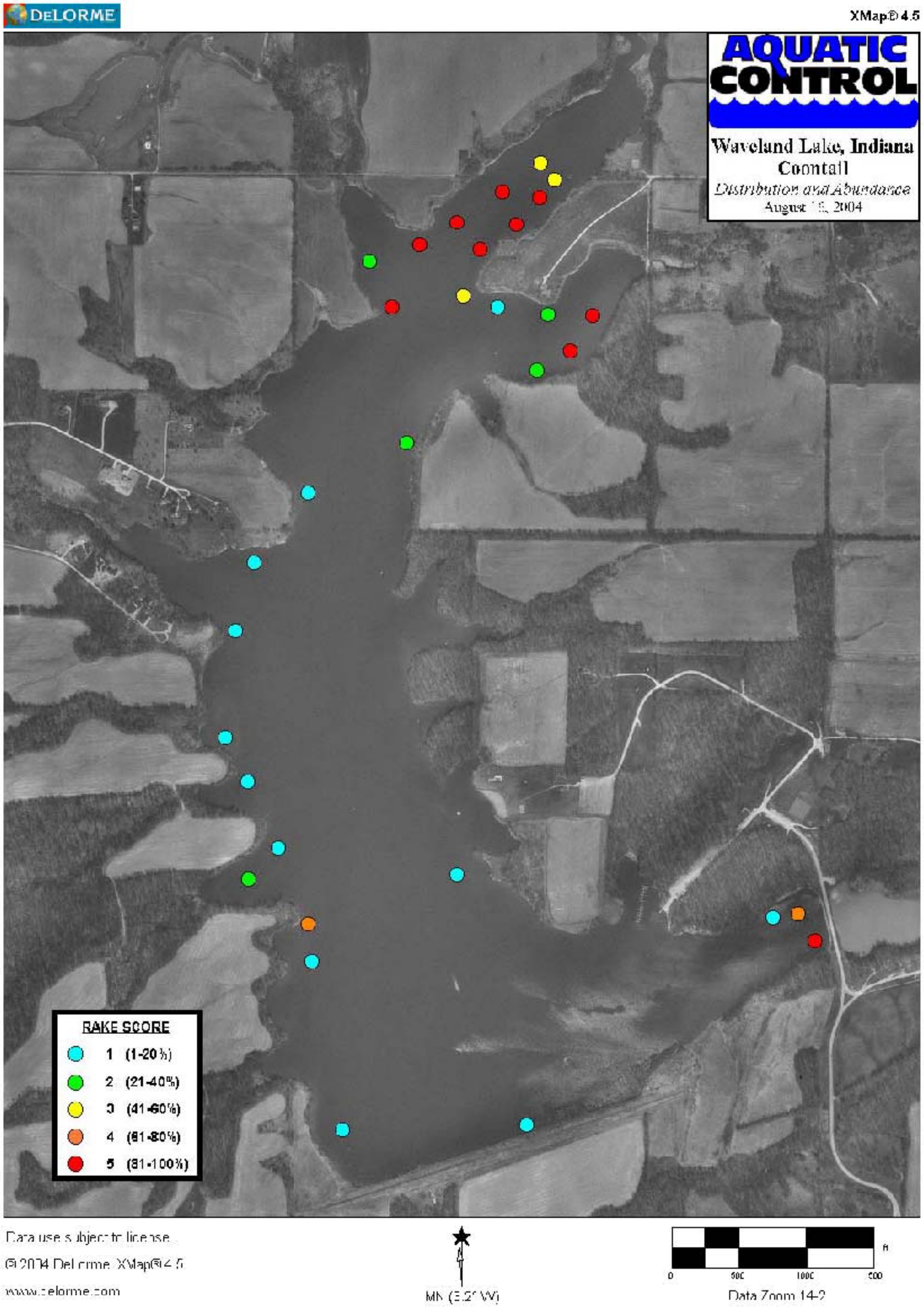
## Appendix B. Maps

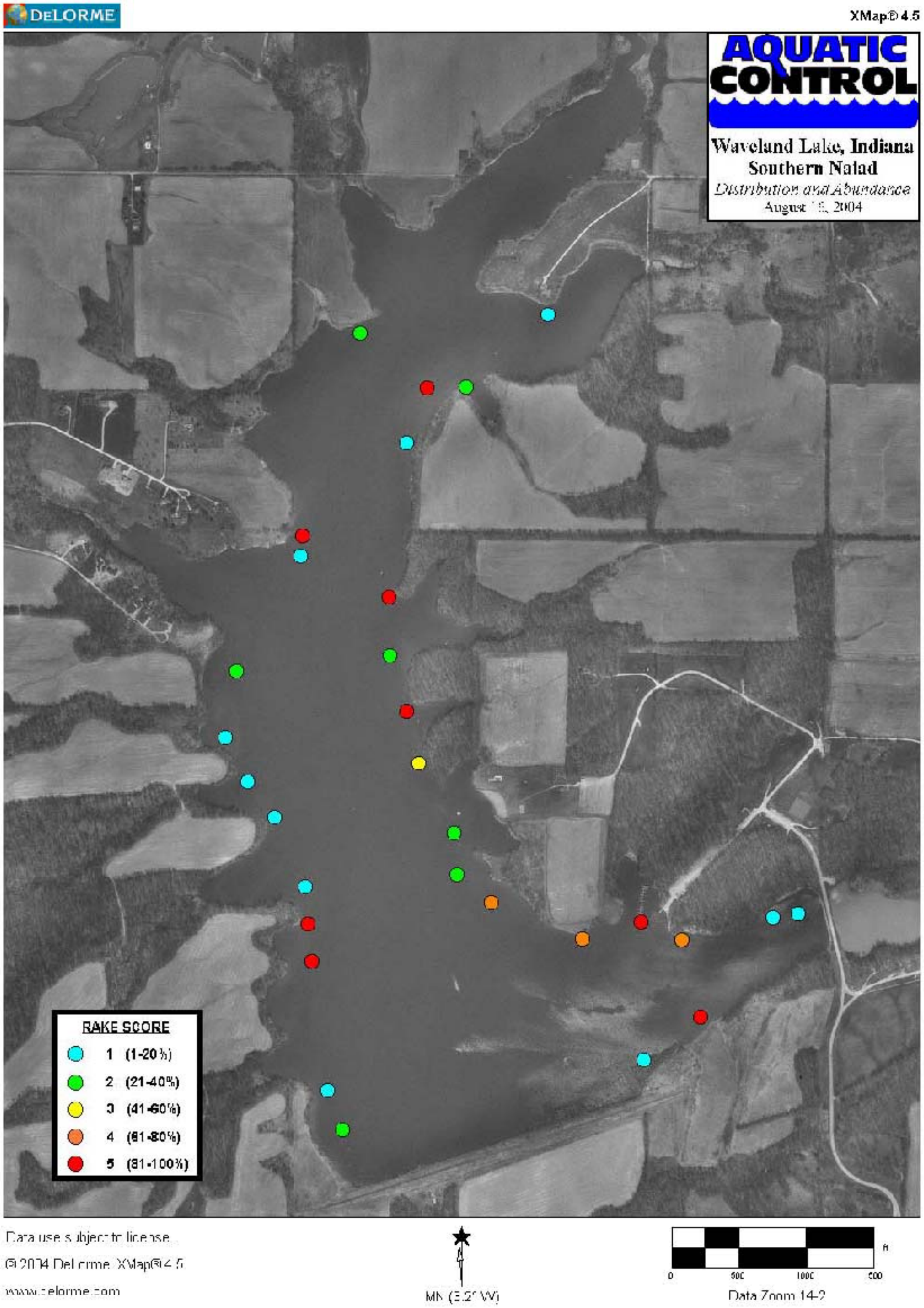


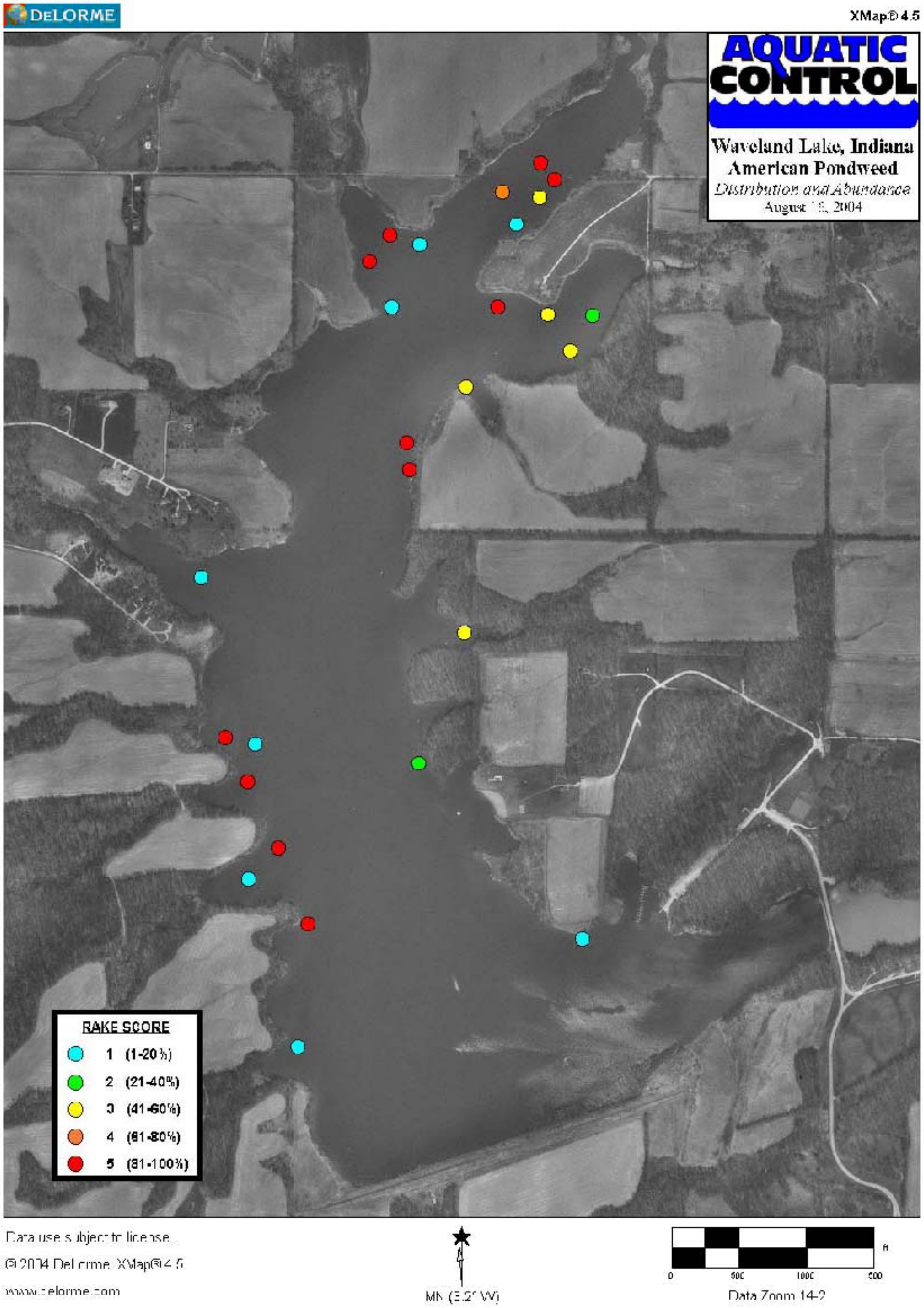

DELORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Plant Beds
August 16, 2004
Plant Bed #2
Plant Bed #3
Plant Bed #4
Plant Bed #1
Plant Bed #5
Data use subject to license.
© 2004 DeLorme. XMap® 4.5
www.delorme.com
Data Zoom 14-2

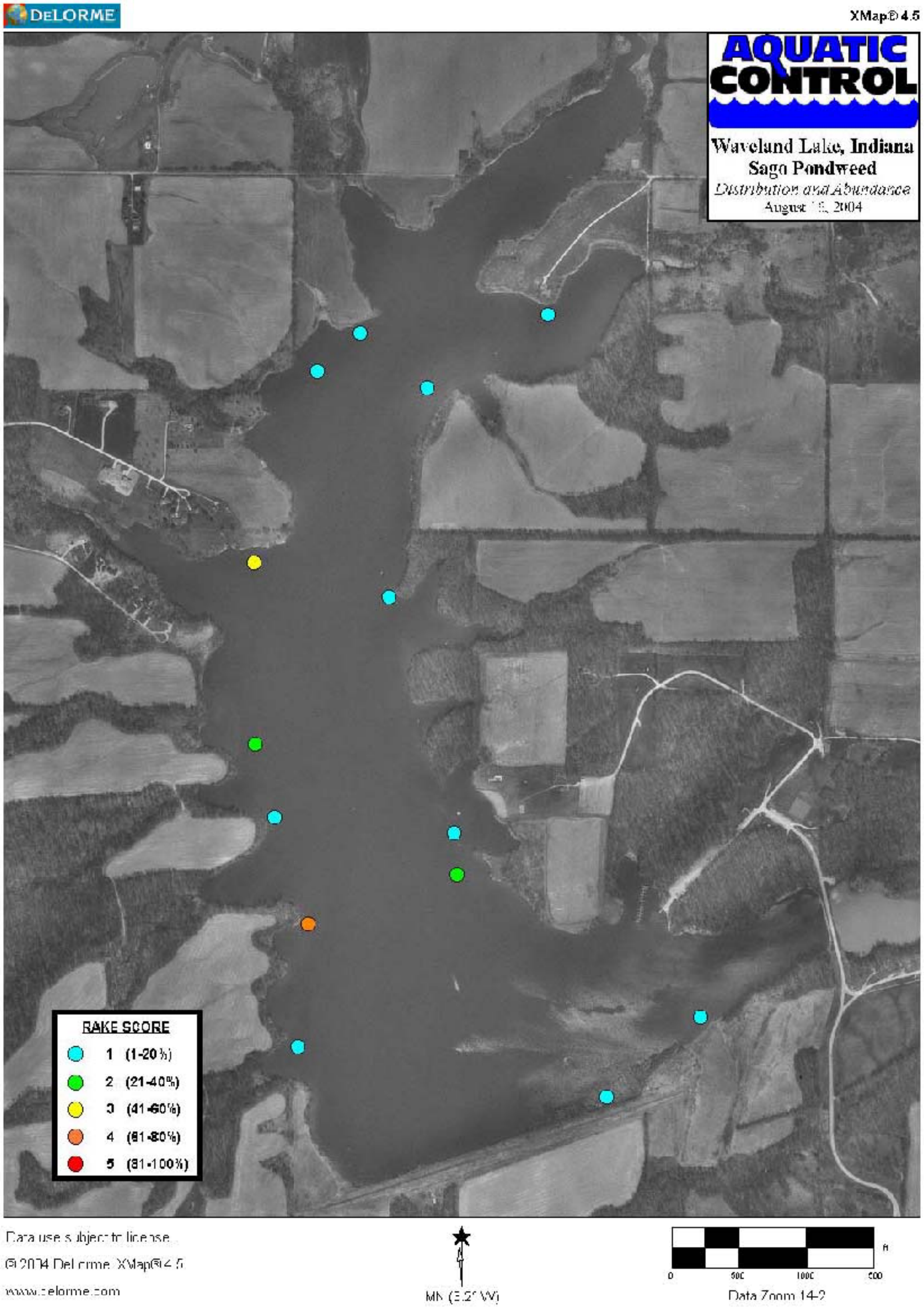

DeLorme
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Sample Points
August 16, 2004
Data use subject to license.
© 2004 DeLorme. XMap® 4.5
www.delorme.com
MN (3.2° W)
Data Zoom 14-2

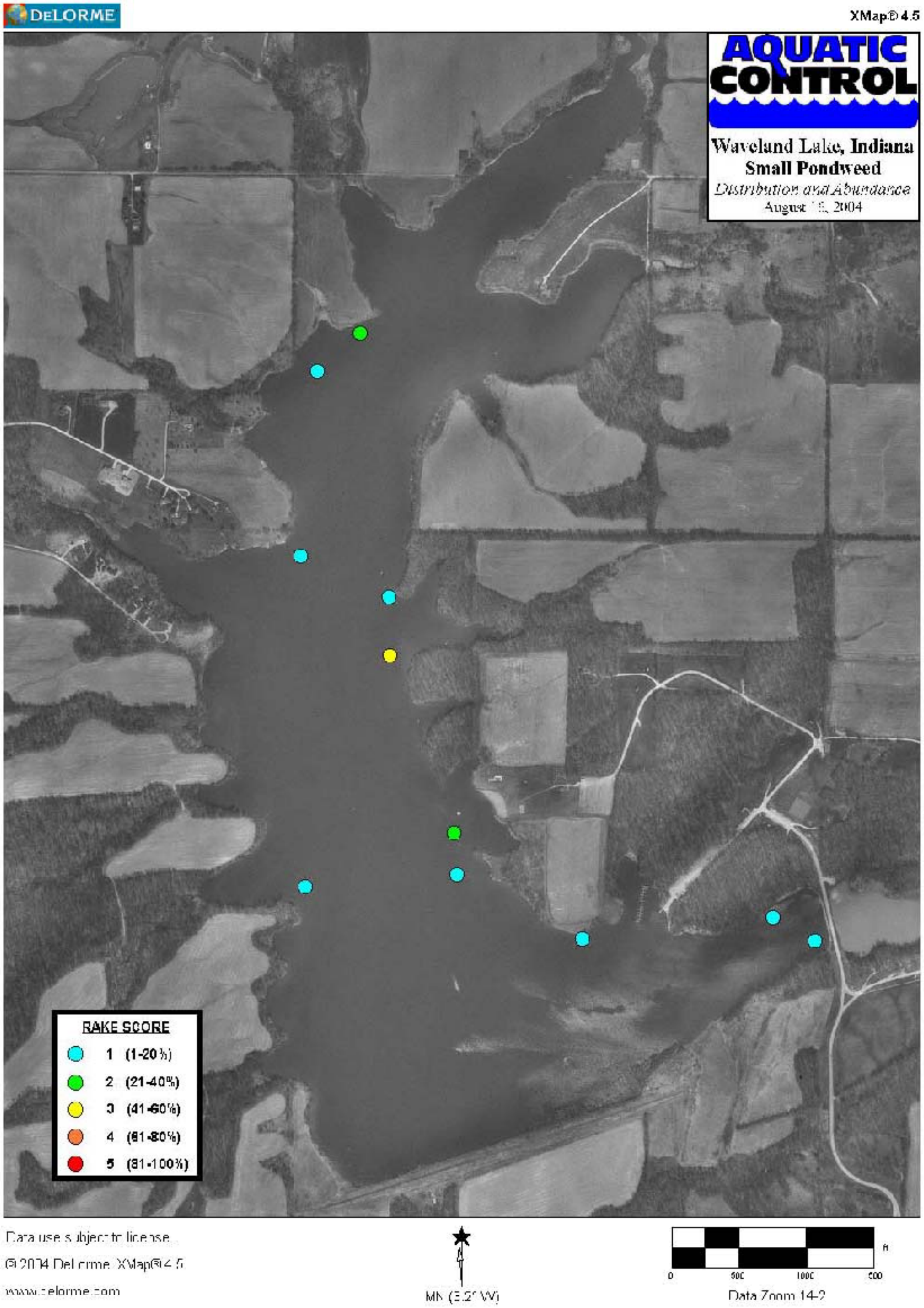

DELORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Aquatic Vegetation
Distribution and Abundance
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
©2004 DeLorme. XMap® 4.5
www.delorme.com
Data Zoom 14-2

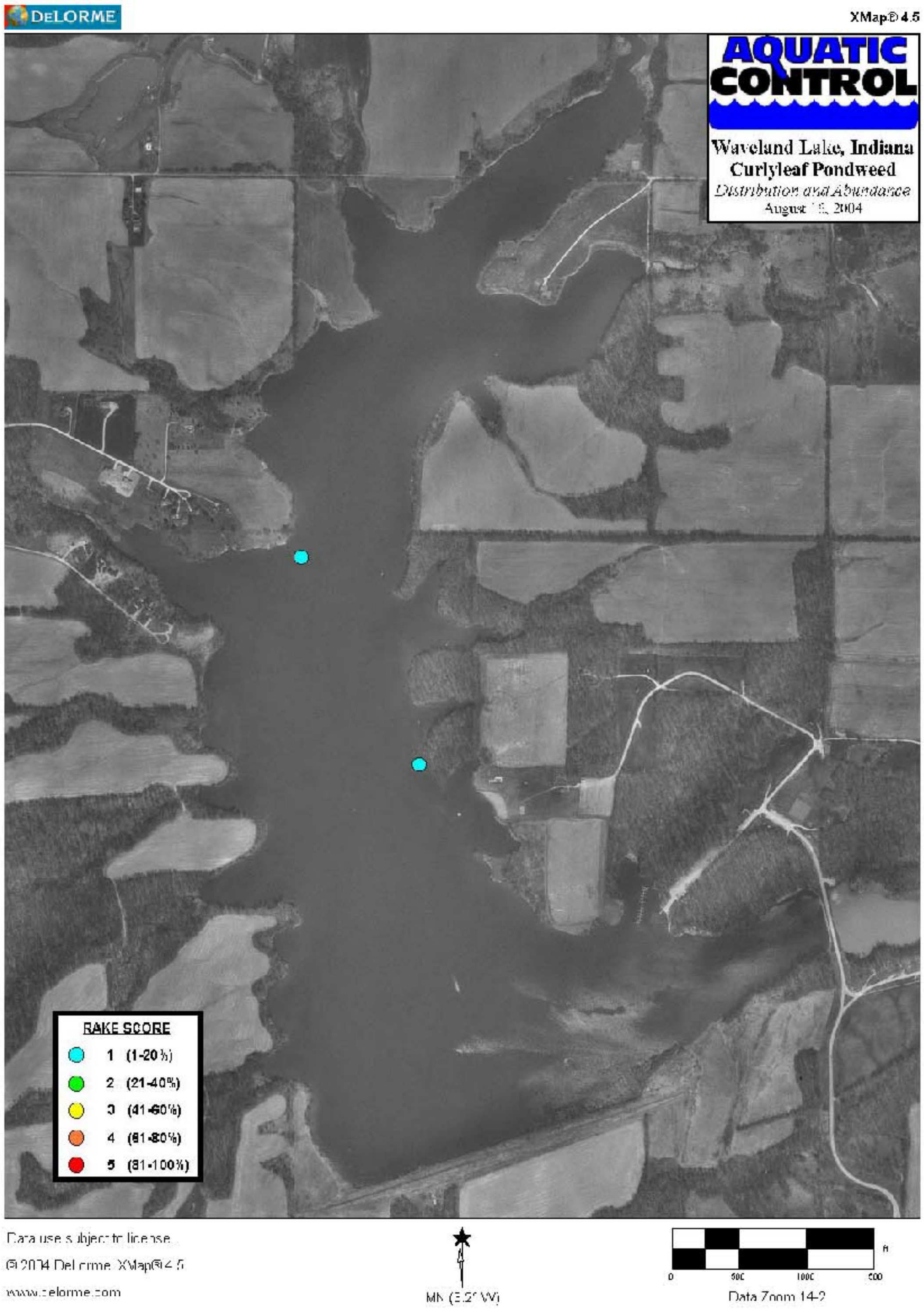

DELORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Coontail
Distribution and Abundance
2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5
www.delorme.com
Data Zoom 14-2
0
500
1000
ft

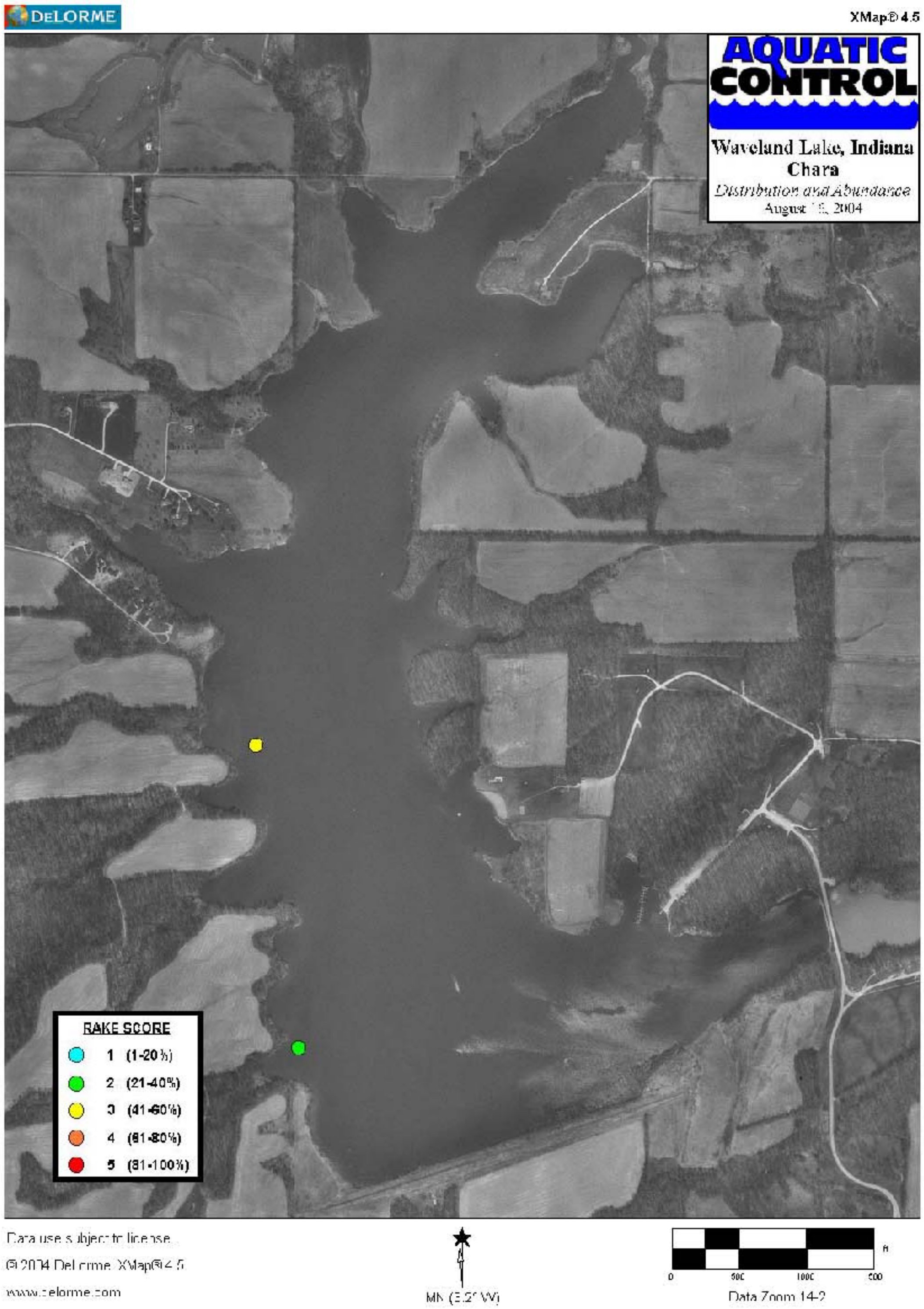

DELORME
XMap® 4.5
Waveland Lake, Indiana
Southern Naiad
Distribution and Abundance
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
www.delorme.com
Data Zoom 14-2


DeLORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
American Pondweed
Distribution and Abundance
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5
www.delorme.com
MN (3.2° W)
Data Zoom 14-2


DeLORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Sago Pondweed
Distribution and Abundance
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5
www.delorme.com
MN (3.2° W)
0
500
1000
ft
Data Zoom 14-2


DELORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Small Pondweed
Distribution and Abundance
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5
www.delorme.com
Data Zoom 14-2


DeLORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Curlyleaf Pondweed
Distribution and Abundance
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data Zoom 14-2


DeLORME
XMap® 4.5
AQUATIC CONTROL
Waveland Lake, Indiana
Chara
Distribution and Abundance
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5
www.delorme.com
Data Zoom 14-2


DELORME
XMap® 4.5
Location of Eurasian watermilfoil plants
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.2° W)
0 450 900 ft
Data Zoom 14-0

POTENTIAL TREATMENT AREAS

# Appendix C. Tier II Plant Sampling Data

| Lake | Date | Latitude | Longitude | Site | Depth | RAKE | POCR3 | CEDE4 | CH?AR | POPE6 | POPU7 | NAGU | PONO2 | ALGA | SpeNum | NatSpeNum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Waveland | 8/16/04 | 39.88804 | -87.08109 | 1 | 2.5 | 5 | | | | | | 4 | | | 1 | 1 |
| Waveland | 8/16/04 | 39.88839 | -87.08216 | 2 | 6.5 | 5 | | | | | | 5 | | | 1 | 1 |
| Waveland | 8/16/04 | 39.88806 | -87.08371 | 3 | 2.5 | 5 | | | | | 1 | 4 | 1 | | 3 | 3 |
| Waveland | 8/16/04 | 39.88879 | -87.08611 | 4 | 4.0 | 5 | | | | | | 4 | | | 1 | 1 |
| Waveland | 8/16/04 | 39.88936 | -87.08703 | 5 | 6.0 | 4 | | 1 | | 2 | 1 | 2 | | 1 | 4 | 4 |
| Waveland | 8/16/04 | 39.8902 | -87.08709 | 6 | 6.0 | 5 | | | | 1 | 2 | 2 | | | 3 | 3 |
| Waveland | 8/16/04 | 39.89162 | -87.08802 | 8 | 3.0 | 5 | 1 | | | | | 3 | 2 | | 3 | 2 |
| Waveland | 8/16/04 | 39.89267 | -87.08833 | 9 | 4.0 | 5 | | | | | | 5 | | | 1 | 1 |
| Waveland | 8/16/04 | 39.8938 | -87.08877 | 10 | 6.0 | 5 | | | | | 3 | 2 | | | 2 | 2 |
| Waveland | 8/16/04 | 39.89416 | -87.08779 | 11 | 8.0 | 1 | | | | | | | | | 0 | 0 |
| Waveland | 8/16/04 | 39.89427 | -87.08681 | 12 | 2.0 | 5 | | | | | | | 3 | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.89498 | -87.08879 | 13 | 2.0 | 5 | | | | 1 | 1 | 5 | | | 3 | 3 |
| Waveland | 8/16/04 | 39.89588 | -87.08872 | 14 | 14.0 | 0 | | | | | | | | | 0 | 0 |
| Waveland | 8/16/04 | 39.89756 | -87.08826 | 15 | 3.0 | 5 | | | | | | | 5 | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.8981 | -87.08833 | 16 | 3.0 | 5 | | 2 | | | | 1 | 5 | | 3 | 3 |
| Waveland | 8/16/04 | 39.8992 | -87.08779 | 17 | 3.0 | 5 | | | | 1 | | 5 | | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.89922 | -87.08677 | 18 | 2.0 | 5 | | | | | | 2 | 3 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.89967 | -87.08615 | 19 | 4.0 | 1 | | | | | | | | 1 | 0 | 0 |
| Waveland | 8/16/04 | 39.89957 | -87.0849 | 20 | 6.0 | 2 | | 2 | | | | | | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.89997 | -87.08401 | 21 | 5.0 | 5 | | 5 | | | | | 3 | | 2 | 2 |
| Waveland | 8/16/04 | 39.90068 | -87.08343 | 22 | 3.0 | 5 | | 5 | | | | | 2 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.90069 | -87.08461 | 23 | 5.0 | 5 | | 2 | | 1 | | 1 | 3 | 1 | 4 | 4 |
| Waveland | 8/16/04 | 39.90084 | -87.08593 | 24 | 5.0 | 5 | | 1 | | | | | 5 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.90108 | -87.08684 | 25 | 5.0 | 3 | | 3 | | | | | | | 1 | 1 |
| Waveland | 8/16/04 | 39.90201 | -87.0864 | 26 | 6.0 | 5 | | 5 | | | | | | | 1 | 1 |
| Waveland | 8/16/04 | 39.90252 | -87.08544 | 27 | 5.0 | 5 | | 5 | | | | | 1 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.90307 | -87.08484 | 28 | 4.0 | 5 | | 5 | | | | | 3 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.90342 | -87.08445 | 29 | 3.0 | 5 | | 3 | | | | | 5 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.90375 | -87.08481 | 30 | 2.0 | 5 | | 3 | | | | | 5 | | 2 | 2 |
| Waveland | 8/16/04 | 39.90318 | -87.08582 | 31 | 6.0 | 5 | | 5 | | | | | 4 | | 2 | 2 |
| Waveland | 8/16/04 | 39.90255 | -87.08702 | 32 | 6.0 | 5 | | 5 | | | | | | | 1 | 1 |
| Waveland | 8/16/04 | 39.90211 | -87.08799 | 33 | 3.0 | 5 | | 5 | | | | | 1 | | 2 | 2 |
| Waveland | 8/16/04 | 39.9023 | -87.08877 | 34 | 3.0 | 5 | | | | | | | 5 | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.90177 | -87.08931 | 35 | 4.0 | 5 | | 2 | | | | | 5 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.90084 | -87.08874 | 36 | 5.0 | 5 | | 5 | | | | | 1 | | 2 | 2 |
| Waveland | 8/16/04 | 39.90033 | -87.08957 | 37 | 2.0 | 4 | | | | 1 | 2 | 2 | | 1 | 3 | 3 |
| Waveland | 8/16/04 | 39.89955 | -87.09068 | 38 | 7.0 | 2 | | | | 1 | 1 | | | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.89708 | -87.09095 | 39 | 8.0 | 1 | | 1 | | | | | | | 1 | 1 |
| Waveland | 8/16/04 | 39.89623 | -87.09108 | 40 | 4.0 | 5 | | | | | | 5 | | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.89582 | -87.09114 | 41 | 6.0 | 1 | 1 | | | | 1 | 1 | | 1 | 3 | 2 |
| Waveland | 8/16/04 | 39.89568 | -87.09235 | 42 | 5.0 | 5 | | 1 | | 3 | | | | | 2 | 2 |
| Waveland | 8/16/04 | 39.89537 | -87.09377 | 43 | 5.0 | 5 | | | | | | | 1 | | 1 | 1 |
| Waveland | 8/16/04 | 39.8943 | -87.09284 | 44 | 9.0 | 1 | | 1 | | | | | | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.89348 | -87.09284 | 45 | 3.0 | 5 | | | | | | 2 | | | 1 | 1 |
| Waveland | 8/16/04 | 39.89213 | -87.09313 | 46 | 3.0 | 5 | | 1 | | | | 1 | 5 | 1 | 3 | 3 |
| Waveland | 8/16/04 | 39.89201 | -87.09234 | 47 | 5.0 | 5 | | | 3 | 2 | | | 1 | 1 | 3 | 3 |
| Waveland | 8/16/04 | 39.89123 | -87.09254 | 48 | 3.0 | 5 | | 1 | | | | 1 | 5 | 1 | 3 | 3 |
| Waveland | 8/16/04 | 39.89107 | -87.09193 | 49 | 9.0 | 0 | | | | | | | | | 0 | 0 |
| Waveland | 8/16/04 | 39.89053 | -87.09183 | 50 | 2.0 | 5 | | | | 1 | | 1 | | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.88991 | -87.09173 | 51 | 5.0 | 5 | | 1 | | | | | 5 | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.88927 | -87.0925 | 52 | 5.0 | 3 | | 2 | | | | | 1 | | 2 | 2 |
| Waveland | 8/16/04 | 39.88912 | -87.09101 | 53 | 7.0 | 2 | | | | | 1 | 1 | | | 2 | 2 |
| Waveland | 8/16/04 | 39.88836 | -87.09094 | 54 | 3.0 | 5 | | 4 | | 4 | | 5 | 5 | 1 | 4 | 4 |
| Waveland | 8/16/04 | 39.88761 | -87.09085 | 55 | 6.0 | 5 | | 1 | | | | 5 | | | 2 | 2 |
| Waveland | 8/16/04 | 39.88587 | -87.0912 | 56 | 4.0 | 5 | | | 2 | 1 | | | 1 | 1 | 3 | 3 |
| Waveland | 8/16/04 | 39.885 | -87.09043 | 57 | 4.0 | 5 | | | | | | 1 | | | 1 | 1 |
| Waveland | 8/16/04 | 39.88421 | -87.09002 | 58 | 7.0 | 3 | | 1 | | | | 2 | | 1 | 2 | 2 |
| Waveland | 8/16/04 | 39.88429 | -87.08518 | 59 | 8.0 | 1 | | 1 | | | | | | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.88487 | -87.08308 | 60 | 6.0 | 1 | | | | 1 | | | | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.88562 | -87.08208 | 61 | 5.0 | 2 | | | | | | 1 | | 1 | 1 | 1 |
| Waveland | 8/16/04 | 39.88649 | -87.08059 | 62 | 4.0 | 5 | | | | 1 | | 5 | | | 2 | 2 |
| Waveland | 8/16/04 | 39.8873 | -87.07918 | 63 | 10.0 | 0 | | | | | | | | | 0 | 0 |
| Waveland | 8/16/04 | 39.88801 | -87.07759 | 64 | 7.0 | 5 | | 5 | | | 1 | | | | 2 | 2 |
| Waveland | 8/16/04 | 39.88856 | -87.07803 | 65 | 6.0 | 5 | | 4 | | | | 1 | | | 2 | 2 |
| Waveland | 8/16/04 | 39.88848 | -87.07868 | 66 | 6.0 | 4 | | 1 | | | 1 | 1 | | | 3 | 3 |

| Species Codes | |
|---|---|
| BIBE | Bur marigold |
| CEDE4 | Coontail |
| CH?AR | Chara |
| ELCA7 | Elodea |
| LEMN | Duckweeds |
| MYHE | Broadleaf watermilfoil |
| MYSI | Northern watermilfoil |
| MYSP2 | Eurasian watermilfoil |
| MYVE | Whorled watermilfoil |
| NAFL | Slender naiad |
| NAGU | Southern waternymph |
| NAMA | Spiny naiad |
| NAMI | Brittle waternymph |
| NELU | American lotus |
| NI?TE | Nitella |
| NOAQVG | No aquatic vegetation |
| NULU | Yellow pond lily |
| NYTU | White water lily |
| POAM | Large-leaf pondweed |
| POCR3 | Curly-leaf pondweed |
| POFO3 | Leafy pondweed |
| POGR8 | Variable pondweed |
| POIL | Illinois pondweed |
| PONO2 | American pondweed |
| POPE6 | Sago pondweed |
| POPR5 | White-stemmed pondweed |
| POPU7 | Small pondweed |
| PORI2 | Richardson's pondweed |
| POZO | Flat-stemmed pondweed |
| UTMA | Common bladderwort |
| VAAM3 | Wild celery, eel grass |
| WO?LF | Watermeal |
| ZAPA | Horned pondweed |
| ZODU | Water stargrass |
| Count | 34 |